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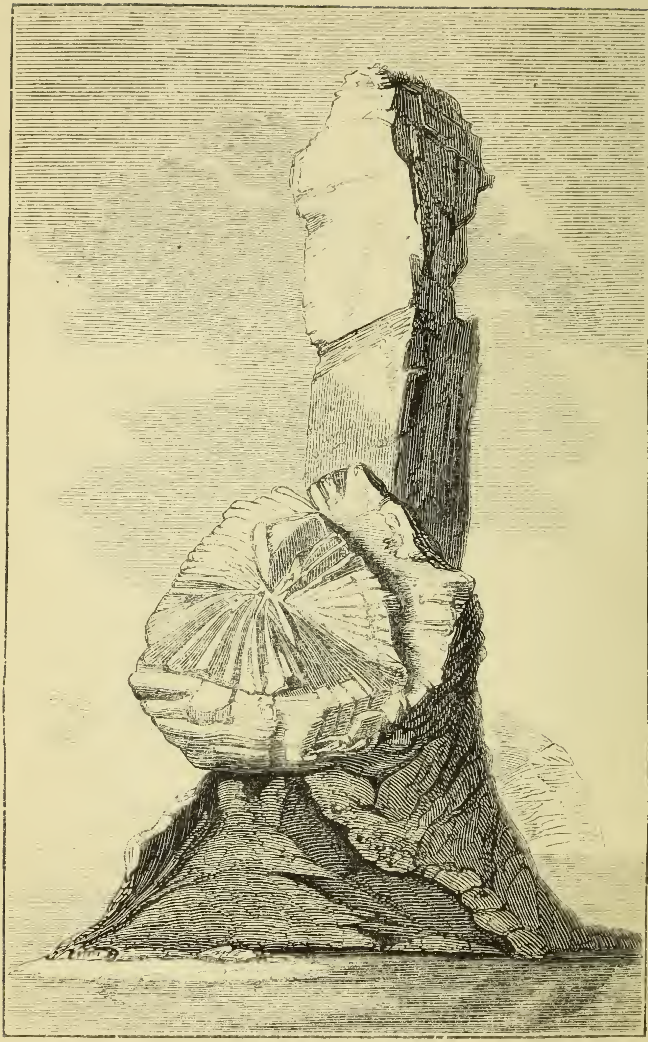

Carboniferous Pinnacle at St. Andrews.

THE MARVELS OF SCIENCE,

AND

THEIR TESTIMONY

TO

HOLY WRIT.

BY S. W. FULLOM.

"There is nothing hidden that shall not be known."

Fifth Edition, Revised.

LONDON:
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DEDICATION.

TO

HIS MAJESTY,

THE KING OF HANOVER.

SIRE,

The sentiments which impelled me to dedicate this volume to your Majesty, as a tribute of my grateful devotion, have, if possible, been deepened by the gracious expressions in which your Majesty has signified your acceptance of the dedication—expressions which can never be effaced from my memory, or my heart.

I am sensible of the many defects of the book, but I feel persuaded that, whatever may be its imperfections, your Majesty will look with

indulgence on a work which, while it appears under the august protection of your Majesty's name, aims to promote the service and exalt the works of the King of Kings.

I have the honour to be,

Sire,

Your Majesty's most humble,

and most devoted Servant,

STEPHEN WATSON FULLOM.

London, June, 1853.

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THE

MARVELS OF SCIENCE.

I.

SCIENCE AND RELIGION.

UNDOUBTEDLY the most precious of man's gifts, invaluable and indispensable as they all are, is revealed religion. In comparison with this, the pleasures and the treasures of the world, and even the endowments of his own nature, sink into insignificance. Without religion, he would stand on the earth a forlorn and desolate being, aimless and hopeless. The very faculties which now contribute so largely to his happiness —which invest him, in fact, almost with the

attributes of a God—his reason, his imagination, and his habit and power of reflection, would tend to aggravate his despair. He would behold himself made but to perish, after enduring a life which, in its best aspect, could be regarded only as a burden. Ignorant of his origin, his nature, and his destination, this wise and elevated being would be confounded by his own superiority, and envy the worm crawling at his feet. A spectacle more harrowing, or more awful, it would be difficult to conceive. Thought, now so fruitful of enjoyment, would then become torture; a sullen gloom would settle on his mind; and, flying from reflection as from a tormentor, he would, if still tolerating life, sink into a savage state, but little removed from the beasts of the forest.

Religion is thus made one of the most essential conditions of our being; and Nature, to use a philosophical term, has not left it unprovided. Apart from Revelation, the mind itself is impressed, at a very early period of its development, with an intuitive consciousness of a superior Power—a Deity, or a fellowship of

Deities, to whom it is subject and accountable. This supplies at once a restraint, a support, and a source of elevation; and so deeply rooted in man's heart is the instinctive conviction of a Presiding Intelligence, that all the inventions of superstition, accumulating through successive ages, till scarcely a vestige of reason or understanding remained, have never completely obscured it. A vague sense of an immortal destiny, and of a supreme, overruling Being, has clung to the benighted mind in the darkest night of its faculties, in its most desperate and most degraded state, raising it up from that slough of despond in which it must otherwise have been immersed. Man has thus, under circumstances of the most depressing tendency, become reconciled to his situation, supported in his reverses, comforted in his sorrows, and ennobled in his duties and aspirations.

If such is the effect produced by mere natural religion, it must be immeasurably enlarged by a faith emanating directly from God, and disseminated by Revelation. Enlightened by such a

communion, man becomes immediately a new creature, inspired by divine sensibilities. His mysterious origin, hitherto so distracting a problem, is unravelled and explained; his mission is defined, and he receives an assurance of perpetuity. Light streams upon his mind, and virtue and self-respect kindle in his heart. His feelings, impulses, and passions, so long ungoverned and ungovernable, learn, with but little effort, the sacred lessons and beautiful restraints of morality, and readily submit to their wholesome discipline. Ferocity, revenge, sensuality, and selfishness, the propensities developed by indulgence, are in great measure abandoned; and the redeemed man is happy, beyond what can be expressed by words, in the assiduous cultivation of forbearance, continence, charity, forgiveness of injuries, and self-denial. He is baptized in knowledge, as well as in faith, and the expansion of his heart induces a corresponding advancement of intellect. He no longer gropes in the dark, embarrassed alike by the past and the present; but walks erect and free, assured of the overruling care of a tutelary

Providence. The earth, basking in this holy light, is no more a gloomy prison, but the threshold of Paradise; and man now succeeds to his appointed inheritance, the empire of Creation.

Revelation being thus inseparably blended with our welfare, and inductive to our progress, it is but reasonable that we should guard its truths with the most jealous care, and deem any aspersion on their sanctity impious and heretical. They are not only the basis of our social happiness, the anchor of our restless minds, associated with every tie and every relation of life; but they give us an assurance, in words intelligible to the meanest understanding, of another life hereafter, to which they are the guide and beacon. In short, we consider them a testament from Heaven, dictated by the Creator himself, and nominating us its heirs.

This holy volume, so replete with knowledge and wisdom, dates from earliest antiquity, though from time to time, as new centuries have rolled by, it has received inestimable augmentations, all throwing new light on our na-

ture and destiny. Up to a certain era, it professes to be a history of our species, and then, with but few digressions, devotes itself more particularly to the affairs of one people, elected to this distinction by a signal interposition of Providence. Even this limitation, however, is anterior, in part, to the long range of ages classified as the historic period; and, therefore, the sacred volume may still be regarded as the annals, less of a race, than of the whole human family. Considered only thus, it is a narrative more valuable and more complete than the most finished record of antiquity, instructing us at once in the history, the geography, the learning, and all the characteristics of those remote times. Travellers in the East are amazed at the accuracy of its descriptions, even where Time, realizing its terrible prophecies, has left but few memorials of ancient habitation. The explorers of ruined cities, entombed for more than a thousand years, find their antiquarian researches mere illustrations of Holy Writ, confirming it in points and allusions previously veiled in obscurity. Monuments rise to light, like witnesses from the

grave, to elucidate and corroborate its historic statements; and the mystic hieroglyphics of Nineveh and Memphis wake from their sleep of ages to bear testimony to its truth. Approaching a more regular chronology, it derives a strange confirmation from the pages of contemporary annalists, removed from all possibility of collusion, and writing in a language entirely different. Later still, it promulgates a new dispensation, inculcating the most exalted precepts, adopted and carried out in a divine example; and the blood of countless martyrs, redeemed from the taint of human error, consecrates this bequest to all posterity.

Man has another guide to the Creator, and key to the mysteries of his being, in the attainments and experiences of his own mind, or what is commonly denominated Science. Science is the witness to Religion—the natural missionary of Faith. It shows us the beauty, the order, and the perfect harmony of the Creation; that it cannot be a thing of chance, but is, in every aspect, infallibly the result of the nicest calculation, directed by supreme wisdom. While

unveiling the lowest depth, our winged tutor carries us to the highest heavens, and, always reverting from effect to cause, traces in every quarter the hand of the same Architect. Science, in short, is an intellectual sun, whose night-dispelling beams fly further than the trackless comet, and unfold to view the whole breadth of the universe. It is a mighty Apostle, who vindicates his ministry by signs and wonders, and is ever leading us to look from nature up to nature's God.

It must not be supposed, however, that Science, so considered, is a spontaneous acquirement. On the contrary, it is the child of Time, matured in the womb of ages. It glimmers through the darkness of space, a faint and far-off beacon, to which man gropes his way, with slow and uncertain steps, over many a tortuous path, beset with delusive phantasma. It is a stupendous mountain, whose every successive steep opens to view some new object, but whose cloud-capped summit, whence we may scan the whole horizon, can only be attained in thousands of years. For centuries its very

elements were mis-stated; and inquiry, however ably directed, was led further and further from the goal. Observation was distorted by prejudice, and every successive deduction was based on error. Man sought in the mine of nature for its gems of knowledge, but laboured without judgment and without light. The marvel was not that, in this dismal uncertainty, he diverged from the right track; but that so many failures and disappointments, and the seeming impossibility of success, did not induce him to abandon the pursuit. His perseverance, however, was destined to achieve a noble and sublime result. Gradually traces of light appeared; precious facts, pregnant with significance, were ascertained and stored; and every new phenomenon was carefully recorded. Then, indeed, men began to build a tower whose top should reach unto the heavens—a tower not made with hands, and which, unlike Babel, was to be a memorial, not of confusion, but of universal harmony and concord.

It is a reasonable consequence that science should be but imperfectly developed in the

infant stage of communities. Our first care is to ensure the means of subsistence, and to provide, as far as possible, for our personal comfort and security. This is a law of nature, and though not absolutely arbitrary, is of almost universal application. Savage or nomade tribes, from their unsettled mode of life, are peculiarly absorbed by these pursuits; and, consequently, have but little acquaintance with physical knowledge. The wild Indian beholds the sun rise in the east, and knows that, as day declines, its orb of flame will sink in the west; but occupied in the excitement of the chase or by the perils of war—taken up by mundane necessities, he seeks no explanation of the phenomenon. The inquiry suggests itself more readily to men independent of these cares—whose employments are less distracting and less barbarous. We owe this first scrutiny of the mysteries of nature to shepherds, who, in the early ages of the world, when beasts of prey still infested the haunts of men, guarded their flocks through the long watches of the night, and then gazed in wonder on the starlit heavens. Minds accus-

tomed to solitary contemplation, uninterrupted by any vicissitudes or startling incident, were immediately arrested by this spectacle, and surveyed its manifold wonders with wistful curiosity. The moon, whose benignant beams softened the terrors of darkness, became, in such a condition of being, an especial object of interest; and the first streak of light rivetted the weary eye of the watcher on the rising sun. In time he learnt to account, by observation and inference, for the recurring phenomena of night and day, conceiving the apparent revolution of the sun and moon to be real, and the earth stationary; and thus, by a process rigidly inductive, gained his first notions of astronomy. Science was cradled in delusion and error.

For thousands of years this vital fallacy, kernelled in the very root of knowledge, was received as a fundamental truth, and deemed indisputable by the learned. Every new phenomenon, however incompatible with such a theory, was distorted into corroborative testimony, and, when that was beyond the greatest powers of reasoning, explained in a manner

utterly chimerical. The hypothesis even acquired the sanction of religion, and was held as an article of faith. It was thought to be established by divine revelation, recorded on the page of Scripture; and when, after countless ages, its fallacy was demonstrated, the great objector, Galileo, was denounced as a heretic and blasphemer.

Behold the aged man in the chamber of the Inquisition, arraigned at its sullen tribunal. Seventy changeful winters have shed their snows upon his brow, which wisdom has impressed with her most majestic characters. The eye whose penetrating glance, directed by the inspiration of genius, has pierced the mysteries of the heavens, now looks on instruments of torture, demanding the renouncement of its discoveries. The world moves, and, knowing this, he is required to declare that it stands fast. He appeals to the clemency and the justice of his judges, and challenges disproof of his statements. He claims indulgence for his failing years, his infirmities, and his life of study and toil. In vain: he cannot witness to a lie; and

the sentence of condemnation, hateful even to the inquisitors, is reluctantly pronounced.

What spectacle so lamentable as that writhing frame, released from the bonds of the rack, and stretched on the damp straw of a dungeon! Shut out from the world, his every limb quivering with pain, the martyr is yet cheered, in his isolation and misery, by the magnitude of his researches. The light his potent intellect has summoned from the sun, will one day be augmented, more than the wildest imagination can conceive, from the confines of infinity. Already the old system of astronomy, with all its intractable theories, and unwieldy suppositions, is for ever destroyed. Like another Sampson, he has plucked up the pillars on which it rested, and the whole cumbersome pile has fallen to the ground. But a new foundation is laid, sure and immoveable as the everlasting rocks, and on this a fabric will rise, spite of the opposing forces of ignorance and superstition, to be a memorial of his genius till the end of time.

Well had it been for the venerable sage if he

had remained faithful to his revelation! What were the sands of an exhausted life, rapidly running out, in comparison with the admiration and esteem of all posterity! But the philosopher, divine in the vigour of his understanding, was human in his weakness. The alternative offered was the stake or recantation—and he decided to recant!

Kneeling in the court of the Inquisition, with his eyes raised to the heavens he had explored, his faltering lips renounced their glorious and holy mission. Clasping the testament of salvation to his bosom, he pronounced the first truth of nature, on which the whole Creation was based, to be a false and heretical fable; then murmured in a low voice—"For all this, it moves."

YES! the truth was uttered; and once put on record, all the devices of man, backed by his most malignant prejudices, would fail to refute it. It was eternal and immutable—as immutable as the world itself. God, of whose laws he was the chosen interpreter, had made it the governing principle of the universe, and such it should remain for ever and ever.

We now see the association that exists between science and religion, and how one testifies, with resistless force, to the divine authority of the other. We have arrived at the primary elemental truth—the earth moves ; and we have now to consider, as briefly as the subject will permit, what are the various relations of this capacious globe, and how it is connected with the sidereal heavens. We may then view it in its structure, its geological history, its ever-changing phenomena, its vegetation, and its inhabitants.

II.

THE EMPIRE OF THE SUN.

The Earth is one of a group of orbs, which circle round the sun, and hence are called the "Solar System." The cluster consists of twenty-eight primary orbs, or planets, so named from their perceptible motion, the term signifying "wanderers"—at least twenty secondary planets, or moons, which revolve round the larger masses; a number of aerolites, familiarly designated "shooting stars," and a host of comets. Six of the primary planets, just distinguished by names, were discovered during last year (1852); three by foreign observers, and three by Mr. Hind. Astronomers

include in the system a ring of vaporous matter, lying in an apparently pyramidal form, beyond the orbit of the earth, and which bears the name of the Zodiacal Light. The whole forms a thin stratum in the heavens, on the plane of the Milky Way.

The control of the vast group is vested in the sun, which, by unerring laws, at once sustains it in space, and holds it in complete subjection. From this mighty orb the cluster is overlooked, and stability carried, on the wings of light, to its remotest frontier. The aspect of the sun accords with such supremacy of position, and is unrivalled in magnitude, in lustre, and in majesty. The immeasureable sphere of heaven, in which our entire system is less than a span, seems his exclusive domain; and when his glorious effulgence bursts forth, all other luminaries disappear. Throughout the broad expanse of his stupendous empire, if we may judge from the effect visible to ourselves, he exercises the same benignant, kindly, and exhilarating influence. To our Earth he extends

the genial blessings of light, warmth, and ever-recurring fruitfulness. His beams, spreading from furthest East to the remote West, shed unmingled gladness over the face of nature, and cover her naked form with a rich mantle of vegetation. He clothes the stately forest with foliage, and carpets the rugged ground with verdure and flowers. The waters sparkle under his light; and the refreshing shower, exhaled by his rays, descends to cool and fertilize the earth. To him we owe the successive and charming variety of the seasons, which bring us, first, the snows of winter, driven onward by the fierce blasts of the North; then, in regular and unbroken order, the promise and lovely blush of spring, the glorious fulness of summer, and the mellow tints of more sober autumn. Through all he is alike ascendant, the monarch of the skies.

This sovereign rule very soon attracted the attention of mankind, and led them to regard the sun with peculiar veneration. Few generations had passed before his attributes and his physical supremacy were recognised, and

in the estimation of the infant world, he was elevated into a god. The renowned sect of the Magians, or fire-worshippers, whose tenets prevailed over a large portion of the East, were his earliest adorers, and their faith was the most primitive of antiquity. They conceived the world to be the work of an eternal God, who combined in himself the opposite principles of good and evil; and that the sun, hung in the highest sphere of heaven, was his flame-girt throne, whence his glance surveyed the universe. Gradually the sun itself became the object of their worship, and at length they even extended their adoration to fire, which, adopting the opinion then universal, they supposed to be the material of the guardian orb, and consequently sacred and divine.

Although the self-luminous stars which so thickly stud the heavens, further than the eye can penetrate, are possibly but the centres of numberless other systems—beacons in the sky to worlds as perfect and as vast as our own, but far removed from human observation—our sun, whose every movement has been so

thoroughly investigated, is the only luminary absolutely ascertained to be a central body, indissolubly linked with subordinate and dependent globes, moving in orbits round it. It is, however, placed beyond dispute, that there is no one mass of matter positively isolated, but that all are alike influenced by extraneous bodies, subject to the same unerring law. This law pervades the universe, and is the principle of mutual attraction, by which these floating worlds, acting and re-acting on each other, are buoyed up for ever in the aërial ocean of space. Thus the moon is knit to the earth, the earth to the sun, and the sun, with its mighty train of planets, comets, asteroids, and moons, to the other clusters of Creation.

The power of attraction is in proportion to the weight and density of the mass; and therefore, in our system, these greatly preponderate in the sun, which holds the other bodies in subjection. Its magnitude indeed is too prodigious for the human mind to comprehend, presenting a diameter of 883,000

miles, while its weight is no less than 354,936 times greater than that of the earth. This stupendous preponderance completely negatives the effect which the planets, obedient to the law of gravitation, would otherwise exercise on each other, and which is consequently restricted to mere perturbations, causing no disturbance of the system, but contributing, by the counteraction, to insure its stability. Till very recently, no such guarantee for its permanence had been discovered, and it was supposed to contain within itself the germ of dissolution. The orbit of the earth, originally an ellipse, was observed to be gradually changing, and in time, say in the course of tens of thousands of years, must become circular, whence it was erroneously inferred that the revolving planet would eventually be precipitated on the sun, and all nature be destroyed. But it is now ascertained that on attaining the circular orbit, the earth will slowly and imperceptibly alter its track, and return, by degrees apparent only after thousands of revolutions, to its primitive ellipse—so wonderfully has God constructed

the universe, and so apparent is the divine hand in all its arrangements!

The sun is separated from the earth by a gulph of 90,000,000 of miles, yet, illimitable as this space seems, its light, travelling at the rate of 12,000,000 of miles in a minute, reaches our hemisphere in seven minutes and a half. The emission and diffusion are thus almost simultaneous; but the sphericity of the earth interposing, creates the charming interval of twilight, by which the eye is prepared alternately for the darker shades of evening and the full radiance of morn. The revolution of the world round its axis produces the phenomena of day and night. Its circuit round the sun marks the ever-recurring year.

I have mentioned the mutual attraction of the planets as an evidence of design in the construction of the heavens, inseparable from the great first cause of an all-wise Creator; but as we advance in the survey of our system, this design becomes more obvious, and the power of attraction is exhibited in a more striking manner. In fact, our scheme of worlds

is so nicely adjusted, each one is balanced so accurately against the other, that were it possible for any two to exchange orbits—as Saturn, for instance, to occupy the position of Mars, and *vice versâ*—the whole fabric would be instantly overthrown. The gravitating principle lodged in the sun, though undoubtedly a leading element in the control of the planets, would itself be a cause of derangement, were it not aided and corrected by this provident distribution of forces.

The natural tendency of a body which has received an impulse forward, though it may be restrained for a time by central gravitation, is to fly onward in a straight line; and this disposition is more especially the characteristic of revolving masses, which, by the velocity of their revolution, acquire a centrifugal force, rendering gravitation nugatory. Thus the earth, swayed by the projectile influence, would, after a certain number of revolutions round its centre of motion, break away from its orbit and wander into space, were it not restrained by an equivalent power vested in the other planets.

Nor is the law of gravitation itself essentially a property of matter, inherently fixed upon it by its own nature. The most elaborate researches of science can arrive at no such conclusion, and to those who object to the miraculous in the work of creation, considering the infinite and immeasurable universe the slow result of natural agencies, here is an undeniable and perpetual miracle, which no sophistry can evade.

The effect of the incessant antagonism of gravitation and reciprocal magnetism is strikingly illustrated in the relations of the earth and the moon. The satellite, conforming to the same economy that governs the primary planets, revolves round the world, its centre of motion, in an orbit nearly circular, at a distance of only 240,000 miles; and is thus immediately in the sphere of the earth's attraction. Such proximity, unrestrained by any opposing influence, would, sooner or later, inevitably rend it from its orbit, and drag its shattered hulk on to our globe; but, to prevent such a derangement, a corresponding power is deposited in the sun, which draws the enslaved satellite

in the opposite direction, and so negatives the ascendancy of the earth. The moon is thus confined to her orbit, and the balance of the heavens is preserved.

The relations of the moon to the earth bear, in some respects, a singular resemblance to those which the earth maintains with the sun. I have stated that the orbit of our globe has been slowly changing, and, as time rolls on, will infallibly become circular; and it is now ascertained, on evidence equally decisive, that the moon is subject to a similar aberration.

On referring to the observations registered by the Babylonians, and comparing them with those made in our own time, the faithful satellite is found to have taken several days longer to perform her revolution in those primitive ages, shrouded in the mists of antiquity, than she does at the present moment. From the dark abyss of the past a voice proclaims the startling truth that she is drawing nearer and nearer to the earth—whirling round it, as the moth flies round the flame, faster and closer, till the awful moment arrives when

her balance will be destroyed, and the whole prodigious mass be precipitated on her primary. Reason is confounded at the mere imagination of a catastrophe so overwhelming and tremendous. We cannot believe that the omniscient Creator, perfect in all his works, has left so great a flaw in the mechanism of the universe! Nor is our confidence misjudged. The moon, like the earth, is undoubtedly changing her orbit; but, like the earth, she can diverge only to a certain point. That attained, she retraces her successive gradations of distance, and so falls back to her original curve. Her stability is insured, and she becomes an everlasting witness to the majesty and power of the Almighty.

The intimacy of our connexion with the moon makes itself apparent in the internal economy of the world, over which, rotating on her distant axis, she exercises an influence at once mild and benignant. To her we owe the beneficent action of the tides, which, by their constant ebb and flow, impart a healthful motion to the waters, and conserve their purity

Map of the Moon.

and freshness. To her we are indebted for a thousand ministrations, inextricably associated with our physical requirements. Nor is her usefulness restricted to an active force, operating on the elements of our globe. Leaving his native earth, man plants himself on this dependency, and finds, on looking round, that it is the threshold of the heavens. The everlasting doors are lifted up; and while his eye measures the diameter of the sun, he is able, from this platform, to span the distance of the remotest nebulæ. He is no longer lord only of the world: he has subdued the universe to his rule.

The moon has no inhabitants. Her vast orb is not, like our own, enveloped in a life-breathing atmosphere, more invigorating than Promethean fire. No seas fill her bottomless depths, and no rivulets gush, in crystal cascades, from the secret recesses of her mountains. One mountain, visible even to the naked eye, is of prodigious dimensions, having a diameter nearly as large as England, and rising to the height of the loftiest of the Andes. In other places the tele-

scope, more piercing than lightning, reveals mighty hollows, sinking below the reach of measurement. Clefts yawn from the heart of rocks, and large boulders impend, as if the slightest breath would hurl them into the abyss. A scene more dismal or more awful cannot be imagined. There is no verdure, no vegetation. From the towering summit of Mount Newton, mantled in impenetrable ice, to the lowest cavity of this silent world, all is sterile, lonely, and desolate. The moon is the throne of eternal winter!

Some authors, with little regard to the observations of our eminent astronomers, represent the frozen orb as the theatre of incessant volcanic eruptions, bursting from every part of its restless surface; and, pursuing this hypothesis, even trace the stream of lava in its outbreak from the crater, and deadly progress onward. But there can be no volcanic action where there is neither water nor air; and fire, to burn perpetually, must have other fuel than ice. Investigation, in fact, has established that, whatever may have been its primitive condition, the moon

is no longer subject to volcanic agencies, but lies unchanged through revolving ages, in all the disorder of chaos.

But we must now, for a time, leave our earth and its dependency, and take a hasty glance at the other planets, the neighbouring orbs of our mighty system. And here I would observe that the globe which we inhabit is not the first in the series, but incloses in its orbit two inner worlds, rotating in minor curves round the sun. It does not fall within the compass of this work, which has reference only to the grand outlines of the Creation, to describe these bodies with minuteness; but it is necessary to speak of them individually, and I shall therefore indicate their position and bearings.

The first in order is Mercury, which is only 36,000,000 of miles from the sun, or little more than a third of the distance of our earth. It is the smallest of our primitive planets, being only 1,300 miles in diameter, but from its proximity, it is seen distinctly without a telescope. It performs its revolution round the sun

in eighty-eight days, which is the shortest period of the system.

The second planet of the group is Venus. This, less influenced by attraction, moves in a more protracted orbit, at a distance from the sun of nearly 70,000,000 of miles. Its magnitude is far greater than Mercury's, and nearly equals that of the earth. According to Sir William Herschell, it is enveloped in a dense atmosphere; and Schröter, who subjected it to a severe scrutiny, considers that some of its mountains are upwards of twenty miles high. Venus is supposed to be attended by a satellite.

Nearly 30,000,000 of miles more must be traversed ere we alight on the earth, the garden of the cluster. This planet seems designed expressly by the Creator for the abode of his most favoured creatures. Situated at such a distance from the sun as to enjoy, without intermission, all the brilliancy of his light, its position secures, at the same time, a measured and healthful temperature, and the beautiful variety of the seasons. To render its gifts more complete, it

is furnished with a dependent and subsidiary moon, its constant attendant and satellite, and an unwearying minister to its physical requirements.

We now pass a great boundary of the system, and wing our flight to Mars, which, doubling the circle of Venus, revolves round the sun at the mean distance of 142,000,000 of miles, Mars is smaller than Venus, and scarcely more than half the magnitude of the earth, having a diameter of only 4,000 miles. Its year is 687 days, in which period, rotating swiftly on its axis, it completes its revolution round the sun.

More than 100,000,000 of miles intervene before any other body presents itself, when the system, hitherto so regular, assumes a new aspect, completely at variance with the apparent principle of its economy. Instead of a ponderous orb, surpassing in magnitude the diameter of Mars, we come upon a knot of minor planets, whose size is comparatively insignificant. This remarkable group, the existence of which has but recently been discovered, chiefly through

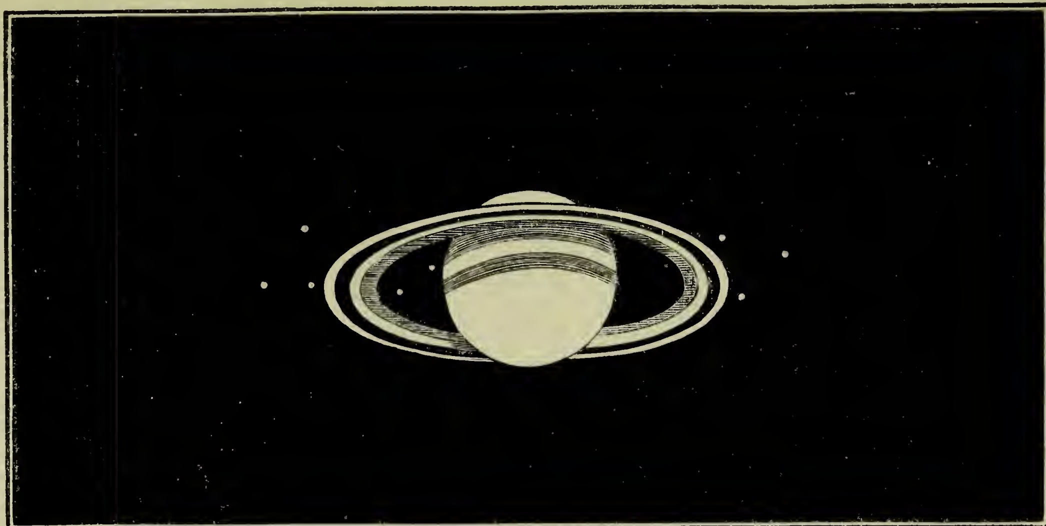
the vigilance and unremitted researches of Mr. Hind, constitutes an anomaly which the most sagacious of our philosophers cannot satisfactorily explain. It consists of no less than twenty planets, describing orbits of varied eccentricity, bent to the plane of the ecliptic and intersecting each other. These bodies are respectively named Ceres, Pallas, Juno, Vesta, Astrea, Hebe, Iris, Flora, Metis, Hygeia, Parthenope, Victoria, Egeria, Irene, Eunomia, Melpomene, Fortuna, Massillias, Calliope, Thalia. Their appearance is so minute that Science, even with its most profound calculations, is unable to determine their precise extent, but probably the largest has not a greater diameter than France. Dr. Olbers, the eminent German astronomer, speculating on so strange a violation of the principle of our system, considers this astral archipelago to have originally formed one compact orb, which some internal convulsion snapped asunder; and, though not very eagerly received, the theory has gained many adherents. It rests, however, on very slender grounds, if I except the elaborate computations of Lagrange—com-

putations which, while they are undeniably subtle and ingenious, are not recognised as evidence by the scientific world. The truth, indeed, seems to be, that this anomalous cluster forms a sort of frontier, a chain of outposts, to those worlds of the system whose orbits it surrounds, and which are essentially distinct from those which lie beyond. Thus the system slowly changes; and a belt of islands, standing like signal towers in the mid-way, forms a connecting link with either extremity.

On turning our attention to the outlying planets, we are immediately struck by their vast magnitude, their compressed form, and the velocity of their motion, so greatly exceeding that of the inner worlds. At a mean distance from the sun of 480,000,000 of miles, we alight on the largest of the series, not inaptly named Jupiter. This brilliant orb, the gem of our system, has a diameter of no less than 90,000 miles, and is twelve years performing its revolution round the sun. It is attended by four moons, revolving in consecutive orbits, the outermost of which is

1,040,000 miles distant. The third moon, while more intimately connected with its primary, is the brightest satellite of our group.

A mighty abyss of 410,000,000 of miles divides Jupiter from Saturn—so far as we yet know, the most peculiar body of the heavens. Surrounded by several luminous and two dark rings, and attended by eight moons, whose lustre its flashing radiance almost throws into eclipse, Saturn presents an appearance at once sublime and awful. Twenty-nine and a half years are required to effect its revolution round the sun, though moving, as I have before intimated, with astounding velocity, so as almost to fly round its axis. The rings in which it is set, inclosing its prodigious diameter of 77,000 miles, revolve with corresponding swiftness, and are so constructed as to insure a perpetual equilibrium, their thickness, from edge to edge, being varied with the most beautiful and consummate delicacy, by which derangement is rendered impossible. This, without doubt, is the most signal, most marvellous,



The Planet Saturn and his Moons.

and most direct indication of the Divine Hand that the whole Creation presents—the most startling exhibition of the Almighty's power, and his unsearchable wisdom, that man has been permitted to contemplate. What a thrill of wonder, what transports of solemn joy, do we not experience, when the piercing telescope lifts the veil of distance, and reveals to us this glorious mystery! Our souls bend in adoration; and we are ready to exclaim in the devout words of the Psalmist: "O, Lord, our Lord, how excellent is thy name in all the world: thou hast set thy glory above the heavens!"

Leaving Saturn, an almost boundless interval succeeds ere we reach another world, when, at the distance of 1,800,000,000 miles from the sun, we arrive at Uranus, long considered the outermost of the planets, but lately dethroned from this dignity. Uranus, differing from the two preceding orbs, rotates with diminished speed, and is eighty-four years accomplishing the circuit of his orbit. In this ceaseless journey he is attended by a retinue of six moons, which

are constantly encircling his path, and ministering to his necessities.

We now approach the confines of our system, where Neptune, our remotest acquisition, moves, like a mighty warder, round his awful and immeasurable orbit, guarding all within. True, at rare intervals, some erratic comet vaults over the dread boundary, and plunges into the void beyond ; but this, followed by the eye of science, only goes forth like an adventurous mariner to sound the depths of that gulf of darkness, and return with the olive-branch of security and order. And here, at the threshold of our group, it will be well to look more narrowly at these wandering bodies, and mark their character and peculiarities.

In the early ages of the world, the appearance of comets in the sky, with tails of greater or less extent, struck mankind with consternation, and was universally regarded as prophetic of calamity and disaster. Nor is this surprising, seeing that the fevered imagination easily distorted their magnificent trains of light into flaming swords, or resolved them into shafts of

fire. It was even announced, from the oracular lips of the priesthood, that the gods, no longer able to forbear, manifested, by these terrific signs, their wrath at the wickedness and corruption of the world, and menaced it with instant destruction. For thousands of years superstition clung to this delusion, and Science, itself wandering in a maze, strengthened it with her more reasonable apprehensions. These met the unwelcome visitant on the remotest frontier of our system, and attended him, with hourly increasing trepidation, in his fearful flight towards the sun. As he still drew nearer and nearer, with a velocity more frightfully rapid, the observer, in a paroxysm of suspense, expected each moment to see his serpent-head dart at the great luminary, and light the universe in flames. Even to within these few years, such a catastrophe was thought within the bounds of probability.

The announcement that Biela's comet, which returns in its track towards the sun every six years, would, on some night in October, 1832, actually cross the earth's orbit, in its passage towards the centre of motion, created a very general

feeling of alarm, and an opinion became extensively diffused, among the intelligent no less than the vulgar, that it was likely to come in collision with our globe. To quiet such idle fears, the eminent astronomer Arago, to whose genius and earnest labours science owes so much, presented to the French Academy of Sciences a most valuable exposition of the characteristics of the intruder, which robs it of all its terrors. It is now demonstrated, on evidence admitting of no dispute, that even if a collision should ever occur—of which there is not one chance in a million—the matter composing the comet is of such excessive rarity, that the earth would pass through it without sustaining any derangement, and without any inconvenience to its inhabitants. On such foundations has God, in his supreme wisdom, constructed our world, and ordained that it shall for ever stand fast!

Comets, from the difficulty of elucidating their character, have been supposed by some eminent astronomers to be worlds in course of formation—the germs of future planets, yet crude and uncondensed. But this theory, though

it has won many adherents, is, in fact, at variance with the whole principle of their economy. Though their flight is so remote, and their motion so eccentric, the limits of their vast orbits are known and defined; and we are able to calculate and foretell their periods, even when extending over thousands of years. Such a result could not possibly be attained by the grandest appliances of science, if the bodies in question were of a progressive character, as, in that case, their periods, to whatever extent they might reach, would infallibly decrease at each revolution. But the theory is opposed by more direct and more conclusive evidence. If comets were really incipient worlds, the matter composing them, as century on century rolled by, would surely condense and thicken, so as to form something more than a mere shell; but, instead of reaching an advanced stage, it rarefies and evaporates. The comet of Halley, which has been traced back for two thousand years when its first appearance is recorded, originally surpassed the sun in lustre, stretching like a beam across the heavens; but from that time, its

figure and magnitude have sensibly altered, and at its last visit, in 1835, it had very materially shrunk. Nor did this diminution of size, still growing beautifully less, arise from condensation, as the nucleus had acquired no increase of density, although, according to the observations of Sir John Herschell, it was sometimes bold and defined.

While it thus seems clear that these flaming visitants cannot be considered in the light of rudimentary planets, the researches of science demonstrate, with equal certainty, that they are not to be regarded with any degree of apprehension. A wondrous discovery has dawned on modern investigation, which most strikingly exhibits the beautiful design and singular harmony of the Creation. The sun, the centre of gravitation, which calls back the wandering comet from its remotest flight, not only attracts, but repels. Sir John Herschell was the first to detect this repulsive power, and to trace it analogically to its source. The great astronomer, whose active genius is ever developing some new truth, asks triumphantly " where

Comet of 1680.

we are to look, if only gravity be admitted, for any reasonable explanation of a comet's projection outward from the sun!" Where indeed, when its natural tendency, under the primary principle of motion, would inevitably be to plunge headlong on the centre of gravity, and destroy the whole fabric of Nature.

The revolutions of the cometary host extend over a wide range of periods. While Encke's comet, one of the telescopic series, performs its uneasy but rapid journey in so short a term as three years, that of 1811 is absent for three thousand and sixty-five, and Encke calculates that the terrific comet of 1680 only returns towards the sun once in 8800 years. During this round of centuries it recedes to the amazing distance of 79,200,000,000 of miles, or forty-four times further than the orbit of Uranus. Even here, however, it is still within the limits of the sun's dominion, and far removed from any ulterior or rival influence. The distance of its centre of motion, as already stated, is 79,200 millions of miles, while that of α Centauri, the nearest of the

stars, is 19,727,000 millions. But the planets of our system have long since disappeared; the imperial sun itself has vanished from sight; and yet, true to the grand law of nature, the obedient comet acknowledges its supremacy. It now moves through the dark ocean of space so slowly, that it scarcely advances a mile in an hour; but soon, by the utter exhaustion of the projectile force, it is again animated by the sun's attraction. Returning on its wild orbit, it gradually increases in velocity, till it dashes with reckless speed into the midst of our system. Thus the sun's ascendancy is vindicated, and proves itself absolute and unbounded.

On considering the whole subject, I think it a reasonable conjecture, in harmony with the known tenor of the Creation, that comets should be the appointed vehicles for the agglomeration of detached vapours—in fact, a sort of police of the skies, preserving everywhere the same uniform consistency and order. Stray exhalations, attracted by the flying mass of the comet, are thus swept from the more defined and precise track of the

planets, where they might exercise a pernicious influence, and being brought into one focus, are subjected to the operation of the sun's heat, by which they are either utterly dispelled, or broken up into fragmentary shooting-stars. This hypothesis solves, at the same time, the enigma presented by those minor outlaws, which have so long eluded the researches of astronomers. And surely it is far more rational to consider the shooting-stars fragments of rarefied comets, thrown off in the manner described, than, as some allege, ejections from volcanoes in the moon, where, indeed, as has already been shown, no volcanic action exists.

We have now surveyed the grand fabric of the solar system, and scanned its wondrous and sublime proportions. We have yet to see that it forms but a speck in the great scheme of the Creation—that the regal sun, vested with such irresistible attributes, is itself but a subordinate —the viceroy of a far mightier lord, throned in the immeasurable distance. To M. Maedler, the eminent astronomer of Dorpat, science owes the startling discovery, that the star Alcyone, in

the Pleïades, is the centre of a boundless succession of clusters, forming what has hence been called an astral system, and of which our sun, with its stupendous train of planets, moons, comets, and asteroids, is but an insignificant unit. So remote from our sphere is this central orb, that its distance can only be marked by comparison, and may be faintly comprehended from the fact that its light, travelling at the rate of 720,000,000 miles an hour, occupies 350 years in reaching our earth.

Such is the awful chasm which divides the sun from its primary; but the interval, wide as it is, is bridged over by the same universal, eternal, immutable law of gravitation. As the moon revolves round the earth, and the earth round the sun, the sun in its turn is bent to an orbit, and is flying round its centre at the rate of 34,000,000 of miles in every year.

The mind would be bewildered in tracing these results, if every step forward, from our first advance, were not an easy sequel—if the mechanism of the whole were not as simple as it is complex—if the harmony that sustains

it were not the effect of known laws, directed by an overruling, inscrutable, and almighty power. But, thus viewed, the sublime spectacle calls up a solemn feeling of joy; and we thankfully remember that the same beneficent Creator who constructed the heavens, far above out of our sight, has declared that none of his creatures are forgotten before him, and that even the very hairs of our head are all numbered.

III.

THE REGIONS OF SPACE.

It it impossible to look up at the heavens on a clear still night, and not be struck with wonder at the countless multitude of stars, spread over its everlasting sphere in every direction. The mind is reluctant to admit, on any other evidence than absolute demonstration, that all those twinkling orbs are grand and magnificent suns—most probably the centres of whole systems of worlds, as vast and as perfect as our own. Even Religion hesitates, as if it were an impious thing to magnify so marvel-

lously the unbounded power of the Almighty, and show the adorable majesty of the Creator in the immensity of His works.

But what shall we say, if we start at this, when the searching gaze of the telescope reveals a cluster of stars for every single one apparent to the naked eye—when far, far away in the illimitable ocean of space, the galaxy of sparkling gems still presents itself, suspended at a distance which the ordinary medium of figures utterly fails to express. The reflection is indeed tremendous, but still suggests an inspiring moral. We feel elevated by the lesson which, awful and occult though it is, we have been gifted with faculties to acquire. The soul finds an anchor in its own endowments, and we worship and glorify the Being who has given such power unto men.

Probably the first point that attracted the primitive observers of the heavens, in considering their structure and economy, was the remarkable configurations of stars composing the twelve constellations, and which still bear the names they received in the earliest ages of

the world. By them the sphere is divided into distinct regions, which serve, by their well-defined boundaries, to mark the position of any individual star. The stars themselves are arranged in five classes—namely, fixed stars, plural stars, lost stars, periodic stars, and new stars. The other celestial bodies constitute the scarcely visible clusters of the nebulæ, and the dazzling stream of the Milky Way.

The Milky Way forms the grandest feature of the firmament. It completely encircles the whole fabric of the skies, and sends its light down upon us, according to the best observations, from no less than 18,000,000 of suns. These are planted at various distances, too remote to be more than feebly understood; but their light, the medium of measurement, requires for its transit to our earth periods ranging from ten to a thousand years. Such is the sum of the great truths revealed to us by the two Herschells, who, with a zeal which no obstacle could daunt, have explored every part of the prodigious circle. Sir William Herschell, after accomplishing his famous section, believed

that he had gauged the Milky Way to its owest depth, affirming that he could follow a cluster of stars with his telescope, constructed expressly for the investigation, as far back as would require 330,000 years for the transmission of its light. But, presumptuous as it may seem, we must be permitted to doubt this assertion, as the same telescope, in the same master-hand, was not sufficiently powerful to resolve even the nebulæ in Orion. Nor must we forget, that light, our only clue to those unsearchable regions, expands and decomposes in its progress, and, coming from a point so remote, its radiant waves would be dispersed in space. Thus the reflection is forced upon us, that new clusters and systems, whose beaming light will never reach our earth, still throng beyond; and that though it is permitted to man to behold the immensity, he shall never see the bounds of the Creation.

From the Milky Way, we turn to contemplate the fixed stars, which constitute the great landmarks of the heavens. Their motion, on account of the tremendous distance, being

scarcely appreciable, they have always been designated as fixed, although, in truth, their periods of revolution are known and defined. Hundreds of thousands of years must elapse before even the shortest term will draw towards its close; and then, as the cycle of time slowly runs out, the swiftest of the fixed stars will have made one circuit round its centre. Their motions are directed by the same principle of gravitation which forms the great law of our own system, though the distance of 61 Cygni, the nearest fixed star, from our sun, is so infinite, that its light, travelling at the rate of 18,000,000 of miles a day, would require ten years for its transit. Fixed stars of the ninth magnitude occupy no less than 580 years in transmitting their light to our globe.

The plural stars, as I have ventured to name them, are that wondrous class which modern researches have proved to have a duplex, triple, and even quadruple character—that is, to be two, three, or four stars merged by distance into one. Under the penetrating gaze of

Herschell, these confederated orbs, apparently so closely linked, were resolved into clusters of suns, revolving in their orbits with the utmost precision, and the most beautiful harmony. Their revolutions extend over the widest imaginable range of periods. Zeta, a double star in Hercules, completes its circuit in thirty-five years. That of a quadruple group in the Harp, composed of two pairs of revolving suns, occupies no less than a million of years.

Amazing as the plural stars appear, a still more startling enigma is presented by the lost stars. The first authenticated disappearance of a star took place in 1790, when Sir William Herschell, the geographer of the firmament, detected the absence of one in Hercules, which, though sought for with the most powerful instruments, has never since been visible. From that time astronomers have been more alert, and numerous other cases have been recorded. The missing stars have, by this close investigation of their movements, been formed into a class, and it is now thought that they are merely rotating on their

orbits, and will reappear on the completion of their respective periods of revolution—perhaps after an absence of thousands of years.

The same theory applies to the movements of the periodic stars, which indeed, by exhibiting similar phenomena in a contracted degree, furnish a clue to the solution of the mystery. A bright star in Medusa, named Algol, is one of the most striking examples of the periodic class, traversing the whole of its orbit in a few hours. Others gradually diminish in magnitude, from one stage to another, for more than a year, when they recover their full lustre. Some suffer complete occultation—probably, as has been very reasonably suggested, by the intervention of opaque bodies, the planets and satellites of those restless systems.

As one class of stars disappears for a time, or vanishes altogether from the heavens, so the eager eye of the astronomer, sweeping over the depths of space, has sometimes been enchained by the dawn of a new star, of which there was no previous record in the registries of science. Not to invoke the equivocal testimony of anti-

quity, I need only mention, as an example of the class, a most remarkable new star that appeared about the middle of the sixteenth century, and remained visible for two years, during which it so increased in lustre, that, at last, it was distinctly seen in the day-time. Gradually declining, it disappeared in the spring of 1575, and has never again been observed.

Several similar orbs have since visited our sphere—travellers from another universe, and after a short sojourn, receded from view in the same manner, emphatically attesting, what I have already ventured to affirm, that far as we may plunge into that dark profound, the boundary, the awful frontier of the Creation, can never be reached by man.

The remotest recesses of the universe, accessible to our present means of observation, are the nebulæ, undoubtedly the most singular objects in the heavens. For a long time baffling the utmost powers of the telescope, they were supposed to be masses of chaotic matter, slowly digesting into new systems. But, whatever

philosophers may dream, the Creation, when examined earnestly, nowhere presents a trace of any inductive process. The great nebulæ in Orion, on which the theory of a chaos was founded, has been resolved by Lord Rosse's famous reflector into stars; and thus the order and beautiful completeness of Nature are vindicated. To the very verge of space, all is regular, fixed, stable, and perfect. The nebulæ of Orion throws its light down upon us from a distance not to be conceived, no less than 60,000 years being consumed in the transit; yet on the equator I have seen this beautiful object, like a soft white cloud on the depths of heaven, with the naked eye. It is bewildering to reflect that such a minute spray of light, covering so small a diameter, should emanate from millions of suns, composing a stream as infinite as the Milky Way; but if we look around, and turn the mighty glass of the telescope on the other principal nebulæ, the awful truth will burst upon our minds, that it is still, with all its clusters of beaming suns, only a fragment of the universe.

The Great Nebulæ in Orion.

We can explore no further; for we have reached the mysterious boundary which no power can pass; and, looking back over the immeasureable abyss, we are only amazed at the achievements of human science. From such a consideration we may well turn to contemplate ourselves—to commune with our own hearts, and be still. We behold the majesty and glory of our Creator exhibited on a scale that, if we have any of the endearing sensibilities of humanity, should at once fill the heart with reverence, and bend the knee in adoration. Sun upon sun, system upon system, obedient to one pervading principle, sweep in unbroken order round the throne of the Most High; and we see His watchful Providence in all His works. Let us pass from great things to small—from the heavens to the world—to ourselves—to the meanest animalcule revealed by the most searching microscope. It is still and still the same. The further we investigate Nature, the more cause do we find to wonder, love, magnify, and adore.

IV.

THE RUINS OF CREATION.

As Astronomy is the parent of the sciences, Geology, the natural sequel of those acquisitions in physical knowledge, may be considered their offspring. Astronomy explores the heavens, and shows us the relations of our world to the external creation: the Earth, originally supposed to be stationary, is now allotted an orbit in the skies, and moves with beautiful precision round her primary. Here Astronomy leaves her; and Geology, taking up the abandoned tablets, becomes her historian.

The theory is at once sublime and startling. It professes, with all the boldness of inspiration,

to trace back the earth through various gradations of condition to its first being—to show the influences which have operated to effect those changes, and to record the origin and development of the mineral, vegetable, and animal kingdoms. It digs in the constituent strata of the earth for the buried secrets of Creation, disinters the crumbled bones of Time, and, to leave no vestige untracked, rifles the awful grave of Nature of her shadowy remains.

But is it expedient to attend a teacher, who, straying from the beaten paths of knowledge, invites us to contemplate such terrible mysteries? We are accustomed to look for light to Heaven, and cannot be persuaded, with the ardent disciples of Werner, that it is to be found in the gloomy depths of the earth. But this is a delusion. Wherever Science penetrates, Religion need not hesitate to follow. We cannot descend so low, but that we shall be able to trace distinctly the adorable finger of God.

Before we investigate the fundamental principles of Geology, and consider its claims to be accepted as a true revelation of Nature, I pro-

pose, in the present chapter, to give a summary of its leading deductions, as exhibited in what may be called the Ruins of Creation. The other question may then be canvassed with more perspicuity and freedom.

The upper structure of the earth is composed of numerous compounds of matter, differing essentially in individual qualities, but blended together by mechanical and chemical agency. These compounds are resolvable, under powerful action, into fifty-four elements, or simple substances, entirely distinct from each other, and naturally incapable of union. In their combined form, they constitute a series of strata, ascending from a certain depth in the earth in proscribed layers, the lowest, as the most ancient, resting on primeval rock, called by geologists the *floor*. Perhaps it might more justly be termed the *roof* of the globe, beneath which, screened from the prying eye of man, Nature conducts her mysterious operations—for here all human researches are arrested. What may be the character of the matter beneath, forming the interior of the planet, cannot possibly be

ascertained; but it is conjectured, as a consequence of the great law of gravitation, that it must undoubtedly be more ponderous and more condensed. The internal heat, too, is supposed to be much greater than that which pervades the upper matter; and Humboldt considers it to increase in the descent so rapidly, that at a depth of thirty miles from the surface, granite, the least impressible of substances, must be in a state of fusion.

The strata of compound matter form what is designated the earth's crust, and though including chalk, clay, and other uncondensed substances, have received collectively, by way of classification, the somewhat arbitrary name of rocks. They present unequivocal evidence of having been originally deposited in water, as the various layers, rising one over the other, are strewn with marine and aquatic remains, and these monuments of a bygone world speak to us as plainly in their shells and fishes, as the proud ruins of ancient Egypt, interpreted by a Belzoni or a Wilkinson, in their mystic hieroglyphics. Plants and trees, many of which must

have enjoyed an existence of a century, ere the storms of time tore them from the soil, and launched them, like the lumber of the modern St. Lawrence, on the wide waste of waters, are among the buried relics of these natural catacombs. Nor do the organic remains, either of plants or animals, belong to families now existent. Some represent tribes which have utterly passed away, and others, though they cannot be considered extinct, survive only in more advanced forms, under new conditions of being. Thus it is held clear that they were subject to physical influences of a totally different character from those which now prevail.

The strata of the earth rarely exceed twelve miles in depth, and frequently are not more than three, the structure below, supporting this ponderous mass, being wholly unstratified. The various layers dip under the plains from one ridge of mountains to another, shaping their declination according to the situation of the heights; and the scale and definite value of the declination, as obtained by the best authorities,

is in proportion to the altitude of the ridge. The order of the strata, however, is by no means perfect, and they frequently present evidence of having been subject to some great convulsion, which has completely perverted their course. Hence arise chasms and distortions, commonly called "faults," which sometimes interrupt the dip, in horizontal extent, for upwards of thirty miles, and throw the whole series into confusion.

Resting on an unstratified basis, cognate in form and substance with the authenticated products of actually existing volcanoes, and which consequently is assumed to be of volcanic origin, the stratified rocks, no longer swept by a boundless ocean, are covered at the surface with a soft, thin coat, called *soil*, composed of the depositions of decayed rocks and plants, and the drift of mountains. The depth of soil is regulated by the situation, and by the character of the stratum beneath; but even in the most favoured spots, where vegetation attains its greatest luxuriance, the layer is only a few feet in thickness. It is almost passed over in the

geological scale of time, as a mere accumulation, of comparatively recent origin, not to be compared with the vast periods previously absorbed, and which themselves beheld but the infancy of the world.

The earth, thus strangely encrusted, is a globe flattened at the poles—the compression amounting, by the calculation of Bessel, to $\frac{1}{299}$. The polar radius, as given by Humboldt, is shorter than the equatorial radius by eleven and a half miles, and the equator has thus an excess of gravitation consequent on the curvature of the surface, equal, according to the same authority, to about $4\frac{3}{7}$ times the height of Mont Blanc. The figure of the earth is such as would naturally result from its revolution on its axis, when in a state of fluidity, having relative freedom of motion, but subject to the control of powerful internal and outward agencies, almost incessantly in operation.

From the igneous compound called granite, which is formed of a combination of crystallized felspar, quartz, and mica, thrown up in confused and unstratified heaps, geologists commence

their chronology, though some, to whom even this latitude is a constraint, imagine that the granite base is but the molten remains of a long range of decomposed strata, ejected from the bottomless gulf below. All agree, however, that the strata above are a deposition from water, amalgamated with ejections of eruptive fluid, and cemented by the infusion of rocks, dissolved by mechanical or chemical action.

From this platform, the mind looks back with consternation through the vast round of ages, to the tremendous moment when, in obedience to the Almighty fiat, our wondrous and mysterious globe, now so perfectly developed, was first called into existence, and comprised only the rudiment of a world. What dread perturbations may have marked its course as, yet new to the great laws of nature, it struggled with the forces that bent it to its orbit, and which met its ponderous frame at every point. It may have sped forward with the velocity of a comet, and suddenly, as it verged on the gloomy abyss of space, have darted round in another direction, and dropped with lightning speed towards the

sun. The great luminary itself was then in embryo, and, perhaps, like the erratic planet, rocked restlessly to and fro. And, to render the picture more terrible, the earth, we are told, was a crude and shapeless mass, without form and void. The water and the land, light and darkness, fire and vapour, mingled confusedly together, formed one promiscuous and irressolvable heap. The future world was still maturing in the womb of Creation.

Who shall fix the date of that occult and awful period? Shall we measure its distance, so shrouded in the mists of eternity, by the feeble range of human comprehension? We are told that time is nothing with God, who counts a thousand years as but one day; yet from a foolish misconstruction, the fallacy of which will be demonstrated hereafter, it is contended that all his prodigious works are of yesterday. Miserable delusion, repugnant alike to reason and to Holy Writ! God is eternal. The very stones cry out to us, as we kick them beneath our feet, that the operations of his hands have been from everlasting, and that

even they have scarcely had a beginning. For millions of years they have been strewn over the land, or have accumulated in the hidden depths of the sea. How much, then, do we circumscribe the majesty of the Most High, when we place such a limit to his dominion. Six thousand years is the age of a tree, not of the Creation!

The fluid mass which swept with such inconceivable velocity, and in a course so uncertain, round its overruling primary, was transformed, at the bidding of the Creator, into a solid and perfect globe. God said, "Let there be light," and the appalling darkness of space, never before broken, was instantly dispelled. The luminous rays burst in a glorious flood over the heavens, and revealed the foundations of the rising universe. Light, so essential to every condition of matter, was separated from darkness, and the mighty work of development proceeded. The waters which were above the firmament were divided, by the creative will, from the waters which were under the firmament, and the dry land ap-

peared. The fire which had kept the whole in fusion was allayed, and receded, with diminished flames, to the interior of the earth. From the dire confusion of chaos arose symmetry and order.

The earth was no longer without form. Moving round the sun in a defined orbit, it was a mechanical result, demanding no direct interposition of the divine power, that it should take the shape adapted to this revolution. Nor are we to suppose that every phenomenon of nature is the immediate effect of a miracle. Such a conclusion would divest the works of God of half their glory; for they are even more marvellous in their mechanism, in the chain of causes on which they depend, than in themselves. All, indeed, is miraculous; but it is in connection with certain definite and immutable laws, which, acting with unerring precision, invariably accomplish their appointed ends: and we may imagine it to be a position worthy even of the Almighty, to contemplate, through the lapse of successive ages, the operation and sublime effect of these great principles,

and the great changes they were gradually, but steadily producing. None will deny that it was in his power to complete at once, and in an instant of time, the whole fabric of the universe; but, in that case, its wonderful structure would scarcely have been so apparent, and we should be unable to trace so clearly the vestiges of his presence.

The spectacle presented by the world on the first separation of its elements was one of frightful disorganization. We may suppose, from the evidence furnished by geology, that the sea rose in tumultuous waves, and, sweeping over the less elevated land, sought to recover the dominion it had lost. Nor was this agitation merely temporary, as the successive elevation of new territories, thrown up by volcanic action, displaced additional bodies of water, and thus continually deranged the level of the ocean. While portions of the land were completely inundated by these deluges, other regions, defended from the sea by massive ramparts, were invaded by monster waterspouts, which, rearing their prodigious columns

to the heavens, tore with equal force over land and sea. In the midst of such convulsions, the earth would rend asunder with terrific violence, in a hundred places at once, and rise in waves as lofty and irresistible as those of the ocean. And to add to the disorder, a thousand volcanoes, communicating with the interior of the planet, made the sky red with their flames, and wrapped the shattered land in a mantle of granite. The heat discharged from so many sources necessarily discomposed the atmosphere, which resounded with endless peals of thunder, and ravaged every quarter with hurricanes and whirlwinds. At the same time, the strata of air were blackened with smoke, and loaded with deadly exhalations.

It was by the combined action of these varied forces, directed by the hand of Supreme Wisdom, that the earth, from being a chaotic heap, acquired a positive and definite figure, securing alike stability and equilibrium. The subterraneous heat expended itself in volcanic action, which, whether manifested in the ejection of lava, or in the no less awful phenomena

of earthquakes, served in an equal degree to elevate, mould, and diversify the surface. While volcanoes were thrown up to the clouds, to kindle them, as it were, with their lurid watchfires, other tracts of the infant globe were spread out in plains, or hollowed into valleys; and thus it acquired that endless diversity of aspect, which adds so much to its beauty.

The great agent in effecting these excavations was water, though it is impossible to say, with any certainty, in what manner it operated. Geologists seem agreed, that denudation was produced mainly by inundations of the sea, but, on considering the magnitude of the results, it seems doubtful whether mere currents could achieve such immense effects. We may suppose the land to have been subject, from time to time, to the wearing action of floods, admitted from the sea by the subsidence of coasts, or by the derangement of the level of the water; but would this cause be sufficient, even in the lapse of countless ages, to wash away the foundations of mountains, and break the huge masses of rock into slopes and dales? Vast areas have obviously been scooped out by

some extraordinary force, which accomplished its mission at once, and it seems probable that this force resided in water-spouts. The power of water-spouts to grind away the very hardest substances cannot be doubted. Even a torrent furrows the side of a precipice, as it plunges madly downward, with a deep and rugged ravine, cut in the adamantine rock, and driven through every obstacle. But the force exerted by a torrent will bear no comparison with that of a water-spout. This potent minister of nature, in her great work of construction and transformation, will alter in a moment the whole aspect of a country, and, considering that it was most likely a phenomenon of frequent occurrence, its effects on the outlines of the early world will readily be understood. Yet it cannot be denied that denudation by means of the sea was also a great source of change. A curiously-shaped rock at St. Andrew's, in Scotland, shown in our frontispiece, is the last vestige of a carboniferous ridge, washed away by this means. The ocean has also left traces of its action in places far beyond its present boundaries, and which remove all doubt as to its having once occupied regions now teeming with vegetation. The waves which

broke, perhaps millions of years ago, on the desolate and gloomy beach, have left the impress of their ripple on the early rocks, an everlasting record of their ebb and flow. Over these registries of the primeval tides rise crags and cliffs, then the barriers of the sea-girt shore. Now they look down on sequestered valleys, or, haply, on ample and expansive plains, leagues removed from the confines of the waters.

It must not be supposed, from these traces of ancient dominion, that the sea ever covered at once the whole surface of the earth. Rocks, or, to use a less technical term, tracts of dry land, have been thrown up from the earliest times. Sir Charles Lyell is even of opinion that various kinds of rocks have originated simultaneously at every period of the world's existence; but probably the oldest of the series, the key-stone of the stupendous masonry, is granite. From this basis rise the fossiliferous rocks, which, after much dispute, have at length been arranged in the following chronological order, beginning with the most ancient:

Primary	Cambrian Silurian Devonian Coal
Secondary	Permian Triassic Oolitic Chalk
Tertiary	Eocene Miocene Pleiocene

Notwithstanding that these successive layers of rock rest, as already stated, on a foundation of granite, it often occurs that granite rises to the surface, while the fabric of strata lies all around it in unbroken order. This incongruous appearance has been mentioned before, as constituting what is commonly designated a fault, and forms a curious feature in the earth's history. Indeed, it is hence made apparent, that although the plutonic structure, viewed as a formation, is undoubtedly the most ancient, it is not peculiar to any one epoch, but is found

in juxta-position with rocks of comparatively recent date. While the latter have been slowly accumulating for thousands and thousands of years, a volcanic convulsion, generated in the interior of the earth, has in one brief instant shattered the whole pile, and injected through the breach a mass of granitic fluid, which has taken the place of the dislocated strata. Thus a tract of igneous origin, hardly to be distinguished from the earth's floor, is frequently enframed by aqueous deposits, the monumental remains of ages long anterior.

The aqueous rocks are divided into primary, secondary, and tertiary. The primary, which are also called *Paleozoic* or *Ancient*, rest on the metamorphic series, which are composed chiefly of siliceous and argillaceous rocks, as gneiss, mica-schist, clay, and slate, with crystallized limestones, and differ but little in their ingredients, and sometimes even in appearance, from the subjacent granite. The argillaceous rocks indeed are but a deposition of granite conveyed by water, and it seems clear that

water was also the medium of deposit for the rocks of the siliceous system. From the testimony of these facts, it is urged, with almost universal assent, that nearly the whole earth was then submerged in a thermal ocean, frequently agitated by violent internal and outward action, which was quite incompatible with any condition of organic life. Traces of vegetable and animal remains, however, have actually been found in the masses of gneiss and mica-schist, and hence these rocks received from Werner the appellation of *Transition*, indicating that they are an advance towards more decided revelations. Some geologists, indeed, have been inclined, from the circumstance of their inclosing organic remains, to include them in the fossiliferous strata, but their crystalline texture, and the nature of their component minerals, seem to have secured their enrolment among the Azoic series. At the same time, it is contended by Sir Charles Lyell, that their crystalline condition is not inherent, but is a transmutation from a fossiliferous state, effected

by the joint means of plutonic action and the superinducement of the metamorphic texture of sedimentary strata.

In the next layers, which are argillaceous in character, with an admixture of arenaceous matter, and constitute the slate system, organic life shows itself distinctly, and in an advanced form of animal. These primitive creatures belong to the tribes of zoophyta and conchifera, and show no defect in their structure, or imperfectness of outline. The rocks themselves present a curious aspect, being of the most motley colours, and occasionally translucent; and, from their composition and texture, are universally regarded as a deposition from water. The group is developed principally in North Wales, and has received the appellation of Cambrian; but though Professor Sedgwick assigns it a very important position, it seems doubtful, from the investigations of Sir R. Murchison, whether it is entitled to any particular prominence.

The strata of slate are overlaid by the Silurian system, an amalgamation of argilla-

ceous, arenaceous, and calcareous compounds, deteriorated in quality, and not very distinctly marked. But the sandstones and limestones of the fabric, though looser in texture, show but little disorder in the stratification, and seem to have accumulated from very protracted deposits. Like the strata beneath, they are diversified in colour, and clearly of aqueous origin, the several layers, the archives of the era, being stored with marine remains. This is thought to explain the remarkable paucity and sameness of the plants, of which, notwithstanding the most zealous researches, only a few fragments have been discovered. Animal life, on the contrary, is widely disseminated, and fruitful of variety. Among the fossils brought to light in England alone are an immense number of Brachiopoda, which have been classed into about a hundred and forty species. The Gasterapoda are also abundant, and there are no less than eighty species of Cephalopoda. The seas swarmed with fishes; and a considerable portion of the engulphed earth, upheaved by internal action, appears to

have risen from the expanse of waters, and formed the basis of the existing land. Indeed, the footprints of a reptile have been detected in a fragment of the Silurian rocks of America, which alone, without other evidence, goes far to establish this supposition. The animal had five feet, and, judging from the impressions, they were each about four inches in length. But what is still more conclusive, a slab of white sandstone, belonging to the Lower Silurian, has been found at Beauharnais, in Canada, marked with the footprints of a quadruped, and it can no longer be doubted that at least a part of the American continent was then reclaimed from the sea. It is assumed, however, that the physical condition of the ocean remained much as before, though there is evidence of violent terrestrial disturbance, and the strata of the system, generally regular, are in many places deranged by igneous rocks, unquestionably the produce of volcanic eruptions.

The displacement of the strata is strikingly

manifested in Wales, where, contrary to all analogy, the slaty beds are curved and vertical, while the formation next above is horizontal. Sir Charles Lyell, however, considers that the dislocation was not caused by any violent subterraneous convulsion, but should rather be attributed to the carboniferous deposits of a later system, which, settling in prodigious masses, produced a local derangement. But it may be contended, the admission of the gifted geologist that the derangement *is* local, and that the strata elsewhere are flat and horizontal, favours the hypothesis of volcanic agency.

The shells and tribolites of the Silurian strata, presenting themselves in such rich profusion, are thought to have exceeded the number at present existing, although, from the imperfectness of the remains, it is extremely difficult to trace many positive distinctions of species. Indeed, the division of the Silurian fossils into zoological provinces is alleged to be impossible, though some assert, with an

equal degree of confidence, that both the animals and flora are infinitely diversified, and admit of easy and accurate classification.

The Silurian system merges into the Old Red Sandstone, or Devonian, so called from the strata of the series found in Devonshire being the richest in organic remains. The group, like that which it surmounts, is divided into Upper and Lower, and includes stone of various kinds and colours, mingled occasionally with marl and slate. In these beds of adamant lie the faded skeletons of numerous species of fish, which, after appearing in different varieties, finally became extinct with the epoch. It was long supposed that the series, while exhibiting a store of marine reliquia, afforded no proof of the existence of land animals, but later researches have elicited some very conclusive revelations in reference to this important point. The late Dr. Mantell, in a memoir read before the Geological Society, describes the discovery in the Old Red Sandstone of Scotland, by Mr. Patrick Duff, of a four-footed reptile, six or seven inches in length. The fossil embraces

the greater part of the skeleton, surmounted by a fragment of the cranium, and, from the structure and outline, seems to be the remains of a small land lizard. Dr. Mantell, however, is undecided whether to consider it purely terrestrial, or a fresh-water Batrachian. To indicate its extreme antiquity, he has given it the name of Teherpeton, from two Greek words, signifying *afar off* and *a reptile.*

On the same occasion, Dr. Mantell drew attention to some fossil ova, found in the lower Devonian shales of Scotland, and which, from certain peculiarities, he pronounced to be eggs of Batrachian reptiles. These interesting reliques are variously disposed, many being clustered together and others isolated, thus in some measure marking the habits and distinctive condition of the depositors. Hence Dr. Mantell, after a careful investigation, has been led to conclude that those found together have been deposited by animals of the frog tribe, while the others, standing by themselves or sprinkled about in pairs, seem to be the ova of aquatic salamanders.

But, perhaps, the most interesting memorial of the Devonian epoch has been brought to light by Captain Brickenden, since it is one that demonstrates, in a manner not to be disputed, that the earth was then peopled by the higher order of animals, simultaneously with those of inferior rank. The fossil represents thirty-four foot-prints of a quadruped, on a slab of Old Red Sandstone, of the upper series, and was hewn out of a rock near Elgin, in Morayshire. Judging from the dimensions of the foot-prints, it was a much larger animal than that found at Beauharnais, in the Silurian rocks of Canada, although, like its precursor, it was probably of the tortoise family, and consequently of kindred structure. Marvellous beyond belief does it seem, that the stride of a creature so insignificant in the scale of Creation, should, after the lapse of millions of years, rise up to testify to the countless cycles of time, and the immutability and eternity of the works of God!

But, while they cannot be considered positively sterile, the archives of the Devonian

group, as far as they have been explored, tell us but little of the natural history of the period, or of what were its main characteristics. The fossils are few, and seem, on the whole, to approximate in character to those of the carboniferous epoch. The flora, being subject to the same influences, probably had a tendency precisely similar, but, as none but marine plants have been discovered, this must for the present be matter of conjecture, and, perhaps, will never be clearly ascertained.

The world, judging from the appearance of the succeeding strata, now underwent a great change, completing one of the immeasurable rounds of Time. From the Devonian series we pass to the Coal, a peculiar, and perhaps the most wondrous section of the terrestrial structure. Ironstone is an important ingredient in some of the layers, and, in the coal-beds, the ore is found in curious conical and spheroidal shapes, one of which, very common in English coal-fields, and aggregated in large masses of prodigious weight, is known among geologists as the "cone-in-cone." But the distinguishing feature

of the carboniferous system is the evidence it affords, in its rich organic memorials, of the great extent of dry land; and it is generally allowed that a portion of England, with some other fragments of Europe, was now covered with a luxuriant vegetation. Till recently, however, no traces of terrestrial animals had been discovered, and the nearest approach to the reptile family was supposed to be the Megalichthys, which, from some similarity in structure, is included in a class called sauroid fishes, alleged to be the link with reptiles. But Sir Charles Lyell has since detected the footprints of a reptile, apparently a large Batrachian, in a series of shales and sandstones opened at Greensburg, in Pennsylvania, containing likewise undoubted coal plants, memorials of the carboniferous epoch; and he also records the discovery of three saurian skeletons, proving beyond dispute the contemporaneous existence of reptiles. Other spoils have lately been recovered from the cemeteries of that ancient world. A tract of shales and sandstone, lying at the base of the Alleghany mountains, retains the footprints of

three distinct species of quadrupeds, which once found subsistence in the carboniferous forests. The footprints of reptiles have been traced in many places, and the skeletons of three, ascertained to have been air-breathing animals, were disinterred a few years ago from the unexplored coal-fields of Germany. Even insects have been embalmed in this sylvan mineral; and the great coal deposits of Europe, once more laid bare, have yielded up the remains of several species of beetles, and the fragile carcase of a moth.

Among the inhabitants of the waters, the mollusca, favoured by the new condition of physical influences, formed a considerable section, and a swarm of brachiapodous bivalves appear in their ranks, giving a singular aspect to the period. The zoophyta, found chiefly in the calcareous masses, are not particularly numerous, but comprehend various species of crinoidea and polyparia. The plants of the system are very abundant, and, in fact, form the entire mass of the coal. Being indisputably of terrestrial growth, geologists, while alleging the strata to be of aqueous derivation, are at issue as to

the exact agency by which they were deposited. By many they are regarded as the ruins of various distinct elevations of land, which, under some operation of nature, successively rose and subsided, bearing with them into the dark abyss immense tracts of centennial forest, clothed in all the luxuriance of tropical vegetation. Others conceive them to be mere sweepings from the land, deposited in the bed of the ocean by floods and inundations, or snatched by rapid and headlong waves from the margins of mighty rivers, the Mississipis of the infant world. However derived, the system is most extensively developed in England, and at different points is found descending to an unfathomable depth, or almost bursting from the surface, as if those primeval woods had but just sunk under our feet.

Judging from the texture of the deposits, the carboniferous land, so fruitful in its productions, probably consisted of granite, thrown up in mountain ridges, and numerous insular groups, intersected by broad estuaries, or traversed by a labyrinth of rivers. The

depositions are frequently lucustrine, and indicate súbsidence in the immediate vicinity of land, where the water, yet remote from the contagious influence of the ocean, was evidently fresh. Nor do the fossils exhibit that degree of maceration which would probably have been produced by deposition in the sea, the boughs and branches, and in some instances even the leaves, being singularly perfect. From these reliquia, moreover, it is established, after long controversy, that the vegetation of the era was not confined to ferns, as the adherents of a progressive development have maintained. Not only are trees contained in the coal beds, but they are found in an upright position, with fragments of root attached, showing that, like the ferns, they had grown on the banks of rivers, and, therefore, must have existed in great abundance. It is remarked, however, as a curious circumstance, that this extensive and varied flora does not include any dicotyledons; and it must be admitted that the great mass of the remains is composed of ferns. Many of these attained an extraordinary height,

Carboniferous Flora.

and a fossil Lepidodendron, of the family of Lycopodiums, has been discovered in one of the collieries of Northumberland, which is nearly fifty feet in length.

Of the Sigillaria, to which family most of the carboniferous trees belonged, whole groves have been brought to light, standing erect, with their roots fixed in the ground; and one of these sylvan giants, found in a coal-mine near Newcastle, after presenting a perpendicular elevation of ten feet, bent over, and extended more than sixty feet in an horizontal direction, thus showing altogether an altitude of upwards of seventy feet. The coniferæ of the epoch, which were numerous, also attained a great height, but, in other respects, present little variation from those of the present day.

The excessive fertility of the carboniferous world has led to considerable discussion respecting the precise character of its climate. From the preponderance of ferns, it had been argued that the temperature must have equalled that which now prevails in the tropics; but this conclusion is no longer undisputed.

A new relic, more marvellous than any yet discovered, has been snatched from the fading sepulchres of the Past, to show what was the actual condition of the atmosphere, and clear up a point so full of interest. This witness is RAIN!

Such are the humble agents which the Almighty converts into everlasting monuments of his power! Who could dream that the shower which fell with refreshing coolness on the trees and ferns of primeval forests, was destined by Supreme Wisdom to fulfil also another mission, which should strike angels with wonder. What mind could conceive, that when millions of years had elapsed, when world upon world had been changed, when successive creations had been moulded and swept away, the traces of that grateful rain would be dug from the depths of the earth, and exposed to the inquiring eye of man! Surely we may draw from the same abyss a conclusion yet more precious—that man has been ordained from the beginning, to be the spectator and expounder of the works of God, and that, whatever difficulties

may for a time surround his investigations, ultimately all things will be placed under his feet.

From the coal system we pass to the Secondary series of strata, called also the Mesozoic from two Greek words signifying *middle* and *ancient*. This division consists of four principal groups, which, though preserving a certain affinity in their ingredients, are respectively composed of several inferior formations, frequently differing in their organic remains. In the two lowermost groups, indeed, the distinctive characteristics are not so striking, and for many years they were classed together, bearing, in allusion to their diversified aspect, the significant designation of Paikilitic, or *Variegated*. The underlying rocks, however, are now recognised as a separate group, and have received the name of Permian, from Perm, a district of Siberia, where the fabric has been found in the most complete state. But they may in some respects, for the sake of perspicuity, be still classed with the superior system, called from the

colour of its ingredients the New Red Sandstone, and sometimes Trias, in consequence of the German group, which was discovered subsequently, including three separate layers, known as the Keuper, the Muschelkalk, and the Bunter-Sandstein. The whole structure is composed of a series of granular rocks, based on red conglomerates, and mingled with variously-coloured marls. The conglomerates, which acquire some prominence from their position, are usually stored with pebbles, though these vestiges do not always appear, and in many instances are only sprinkled through the layers. Beds of salt, met with in nearly all the preceding strata, are particularly conspicuous in the New Red Sandstone, whence it was formerly called the saliferous system. The series is developed very fairly in England, though not uniformly, but it covers wide tracts on the Continent, particularly in the North and West of Germany. It would appear, from the preponderance of salt, that the deposits are chiefly marine; but the sea was now gradually retreating to its

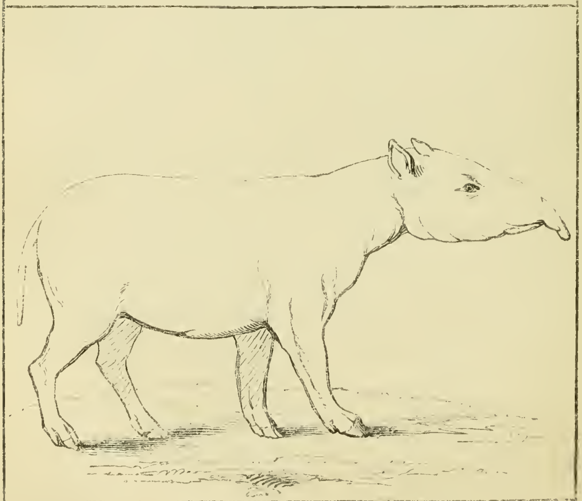
depths, while the earth, relieved from the monstrous pressure, continually threw up fresh elevations of land.

In the organic remains of the series we are presented with imperishable memorials of its history. The ocean, the rivers, the land, and the air, for the first time linked in the great chain of being, have all a share in these fossil monuments. Traces of the footsteps of birds of every size, from the ostrich to the minor genera, have been discovered in the saliferous formations of America, and English ground has rendered up the relics of various species of quadrupeds, though chiefly referable to extinct races. Remains of three different species of carnivorous quadrupeds of the marsupial order, in which the brain appears in a rudimentary form, typical of a low stage of development, have been dug out the saliferous cemeteries of England; and numerous marsupial reliquia have been found in Australia. The protorosaurus and the phytosaurus appear among the oviparous quadrupeds, ascending to the later Oolitic strata; and the fruitful family of reptiles, which embraccs a

great variety of species, takes the same direction. Fishes were abundant; and huge sharks scoured the seas, or floundered in the bays that now indented the swampy coasts, while crocodiles dragged their loathsome forms through the ooze of the rivers.

Perhaps the most remarkable animal of the Triassic epoch, in respect both to shape and proportions, was the Labyrinthodon, a gigantic frog, equal in bulk to a rhinoceros. Traces of this monstrous Batrachian were first discovered at Storton Hill, near Liverpool, where a slab of sandstone was dug up, marked with its footsteps. The enormous length of these impressions and their peculiar appearance—which was an exact representation of the human hand, enlarged to four times its size—excited the greatest astonishment, and for a long time geologists were unable to agree as to the species of animal to which the track could be referred. The discovery of some large Batrachian teeth in the Trias of Germany first lent a clue to the enigma, and it is from the labyrinthine structure of one of these teeth, as seen through a

The Labyrinthodon.



The Palæotherium.—Page 110.

microscope, that the animal derives its name. A jaw and other bones were subsequently disinterred, and at length, after various intervals, nearly the whole skeleton has been recovered. From this it appears, on a careful scrutiny, that the jaws were of an immense length, and furnished with more than a hundred fangs. The skin was probably scaly, and in some parts was encased and protected by ossiferous plates. Two tusks protruded from the mouth, and the size of the animal may be inferred from the fact, now clearly established, that some pieces of the posterior bones, identified with the skeleton, correspond in dimensions with the same parts in a crocodile thirty feet in length.

The Nothosaurus and the Phytosaurus, two singular members of the reptile family, also characteristic of this epoch, have, in company with the Labyrinthodon and other Triassic species, been exhumed from the rich Trias of Germany. Among the Lacertians, the Rhycosaur and the Dycinodon—the latter discovered at the Cape of Good Hope—probably occupied a prominent place; and tortoises and turtles

seem to have been very numerous. But all these relics are thrown into the shade by the footprints of an enormous bird, which, judging from the evidence of its track, must have greatly exceeded the proportions of the ostrich. The impressions left by the toes of this plumed monster are twenty inches in length; and its feet were of fabulous size. Supposing the bulk and height of the animal to be in proportion, we have here a bird upwards of twenty feet high; nor is there any reason to believe, on comparing its footprints with those of the largest living birds, and carefully investigating all the facts, that these dimensions are the least exaggerated.

One series of bipedal footprints found in the Valley of Connecticut, in the neighbourhood of the bird-tracks, is veiled in mystery. The impressions are no less than twenty-two inches long, by twelve in width, and differ, both in form and magnitude, from any yet discovered. The toes, which are four in number, have joints analogous to those of birds, and, in fact, the imprints have been referred to a bird, but the

variations of structure are too decided to sanction this supposition. Nor is the suggestion of Agassiz, founded on the peculiar form of the foot, that the track was left by a monstrous Batrachian—a bipedal frog, which must have exceeded in side the largest elephant—to be implicitly received, though coming from an authority entitled to respect, and usually infallible. Indeed, this relic of a world of monsters, isolated from every other vestige, is still a puzzle to philosophers, and perhaps will never be fully or satisfactorily identified.

Animal life shows itself on a still grander scale in the succeeding Oolitic system, composed of blue or yellow clays, oxidated grits, and coarse Oolitic rocks. At the base lies a formation of argillaceous limestone, marls, and clay, commonly designated Lias. The series, however, is by no means regular, and over a great part of the continent exhibits serious derangements and dislocations, frequently occasioned, as in Scotland, by the eruption of igneous rocks. The whole system, indeed, attests that some great change was at this time accomplished in

the physical condition of the world, effecting a complete re-adjustment of the limits of land and sea.

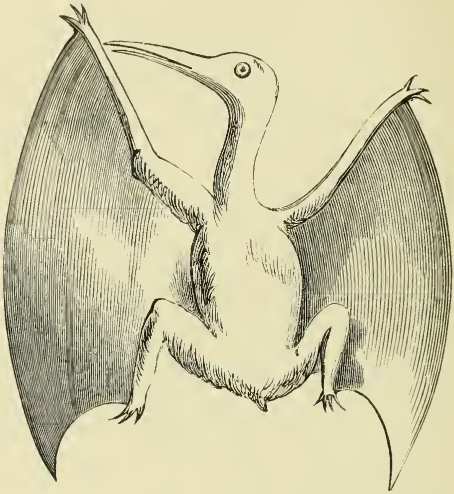
Formed throughout of aqueous sediment, the Oolitic strata are in great measure arranged by molecular attraction ; and shells and other marine exuviæ, the spoil of the receding ocean, enrich their clays and chalks. The group is divided into three sections, the upper, middle, and lower, marking three distinct periods of time, though, on examination, they are found to assimilate in their organic deposits. Articulated and vertebral creatures abound, and the minor forms of animal life, no longer confined to a few species, are as diversified as they are numerous. The rivers, bursting in silvery cascades or rushing torrents from a hundred lofty mountains, afforded aliment in their course to a multitude of univalves and bivalves, and the vast estuaries which received their tributary waters teemed with every kind of fish. Among the mollusca, cephalopoda are the most varied, and appear in amazing numbers. Saurians, both terrestrial and acquatic, are common, though

those of marine habit predominate. The absence of any mammalia higher in order than the marsupial family, now almost confined to Australia, is attributed to the fervid temperature, which is also thought to account for the great abundance and prodigious magnitude of the reptiles.

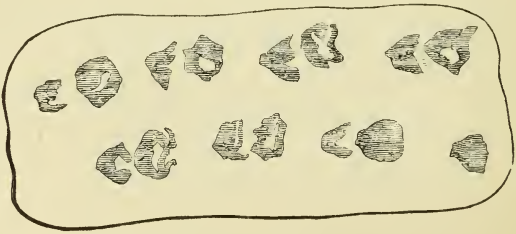
A tropical climate, such as then prevailed, is undoubtedly favourable to the development of the reptile tribes, as the zoology of existing tropical regions amply testifies; and it is no less demonstrable that they are discouraged by cold, the countries bordering the Arctic Sea, which are prolific in mammalia, presenting scarcely a trace of reptiles. But the absence of the higher orders of mammalia from the organic fossils is by no means a proof of their non-existence; and should the negative evidence be admitted, we must suppose that nature, advancing in everything else, in this instance made a retrograde movement, effacing the creation she had already matured. In the succeeding Cretaceous system, indeed, mammalia wholly disappear; and the sea, recently

confined to bounds, seems to be once more supreme.

The Oolitic system is rich in terrestrial vegetation; and trees, including perfect exogens, have been found in England, with fragments of root attached, which are supposed to occupy the exact spot where they grew. The same may be said of its whole range of animals, from the stellerida to the reptiles, the highest organic development it attained. The very genera, viewed by the searching eye of the naturalist, assume peculiarities of structure totally distinct, and while all those of the primary strata have quite disappeared, very few species of even the elder secondary remain. It would seem, therefore, that the world was clearly subject to successive changes of temperature, which gradually developed and destroyed certain specific races; and Hooke is of opinion, that the climate of England now resembled that of the modern torrid zone. The period, however, is one of inextricable perplexity and confusion, presenting no reliquiæ of land, though some important deposits, embracing both



The Pterodactyl.



Footprints in Old Red Sandstone.—Page 81.

animals and plants, are decidedly lacustrine. Where were the channels whence these were poured forth? And why, if the waters had so immensely abated, have they brought no olive-branch from the redeemed land?

Round the delta of the mighty river which at this period swept over England, crawled numerous reptiles, one of which, the Cetiosaurus, was probably about sixty feet long. This king of monsters was furnished with a broad vertical tail, capable of administering a terrific blow; and the toes of its webbed feet, proportioned in size to the prodigious bulk they had to sustain, were armed with sharp claws, with which it fastened on the fish and smaller reptiles constituting its food. The Megalosaurus was another gigantic reptile, which is supposed to have combined with the magnitude of the hippopotamus, the structural peculiarities of the alligator. But the strangest of these hideous creatures, in point of structure and appearance, was the Pterodactyl, a Flying Reptile, formed to subsist both on land and water. The size of the Pterodactyl is variously

F 2

estimated, but perhaps the outstretched wings, from the extremity of one to that of the other, did not quite cover seventeen feet. It was of predacious habits, and its jaw, which was perfectly reptilian in form, was set with about sixty conical teeth, firmly riveted in the bone. The legs appear to have been of considerable length, and adapted equally for walking or swimming. The neck was also long, closely assimilating with a bird's; and the wings, which differed from any organs of flight now existing, possessed extraordinary power, and enabled this aërial scourge to soar to incredible heights, and thence fall like lightning on its destined prey.

The next changes in the physical condition of the world are marked by the cretaceous system, the ingredients of which, originally supposed to consist chiefly of chalk, include a combination of various limestones, chalk, chalk and flints, chalk marl, greensand, and gualt. These deposits, which are of marine origin, rest in some places on a freshwater formation, composed of clay, sand, limestones, and marls, and

known by the name of Wealden. The Wealden is well developed in the south-east of England, and in parts of the continent, particularly in Hanover. On English ground, the aspect it presents is very singular, and among the successive strata, an accumulation called the dirt bed of Portland, composed of decayed vegetation, is especially remarkable. Indeed, it is clear, as well from the character of the deposits, as from the different species of testacea, that the relations of land and sea underwent extraordinary and repeated alterations during the erection of the Wealden, and the denudation to which the land was subject materially affected its figure.

The chalk, from its affinity to modern deposits of a similar character, is thought to be composed, to a great extent, of the ejections of fish, but it has also received considerable contributions from corals, which, indeed, form the entire material of the limestone of Faxoe. It appears to have been a period when, in obedience to some inscrutable law, the sea once more rolled over the land, and only a few isolated

tracts were preserved from the irruption. These solitary islets were frequented by the Mosasaurus, a marine reptile, upwards of twenty feet in length, and by the Pterodactyl, or Flying Reptile, which was still an inhabitant of the earth. From the tall seaweed which encircled the naked shores, the Mosasaurus darted out, with incredible swiftness, on the shark or the whale—for the jawbone of a whale has been found in the elephant bed of Brighton—and as these monsters of the deep gave each other battle, the waters were dyed with their blood. Meanwhile, the Pterodactyl hovered above, and when the fight was won, claimed a share of the lifeless prey. Then another contest ensued, and the recent victor, enfeebled by his previous struggle, either sought safety in flight, or himself became the prey of the winged dragon.

The absence of all fluviatile and floral relics, beyond a little drift-wood, and some fragments of ferns, clearly indicate the marine character of the era, and, therefore, we are prepared to expect that there should be no traces of

quadrupeds. That such animals did exist, however, there can be no doubt, though the islands to which they were confined may have been widely separated, and have hitherto baffled the search of the geologist. It is reserved for some future Columbus, versed in the geography of primeval ages, to indicate their position, and then no doubt a Lyell will arise to disinter their fossils, and bring them once more on the stage of being.

The cretaceous system was followed by another change in the physical condition of the earth, which makes itself apparent, with very unequivocal distinctness, in the succeeding tertiary formations. These comprise three separate periods—the Eocene, Miocene, and Pleiocene. The first includes two minor formations, the Faluns of Touraine and the Molasse of Switzerland, while the whole structure, to the termination of the Pleiocone, marks various gradations of temperature and condition. Large sections of Europe, extending in irregular and fragmentary patches from the then fruitful Arctic

regions to the cloud-capped chains of the Pyrenees and Alps, had now risen to light, and formed a barrier against the encroaching sea. Still the land was traversed by numberless streams, expanding very frequently into lakes and estuaries, or branching off into mighty rivers, which strewed the ocean with sweepings of the soil. The future Paris was entombed in the waters of a Gulf; and London, the destined capital of a later world, was lying in the womb of an estuary. But the spoil of the land was by degrees choking the great marine channels, and the sediment snatched from mountains, or washed from the banks of inland seas, was gradually, as the depositions increased, accumulating into new territories. Vast tracts of marsh and gloomy swamp were thus spread round the land, affording a genial haunt for gulls and sea-birds, and a retreat for the most loathsome of reptiles. Immense forests, whose hoary woods assimilate occasionally with those of the existing world, clothed the rugged heights, or stretched in matted thickets over the hollows;

and as the untold periods of time rolled on, giraffes and rhinoceroses, with monstrous and unwieldy elephants, the huge mastodon and colossal mammoth, had their lairs and dens in these sylvan recesses.

Vegetation became more varied, though perhaps less prolific, as the earth, so long subject to a tropical temperature, first felt the influence of cold. The climate of the Eocene era, however it may have differed from that which prevailed during the secondary epochs, was probably still of a uniform heat, favouring equally the primeval plains of the north and the hills and islands of the south. But, as new eras opened, ice began to collect in scattered but frequent masses on the northern shores of Siberia, and forming into floats and bergs, drifted round the frozen coast to the Atlantic. Such an accumulation necessarily affected the atmosphere, and the whole region of the North, exposed to these combined influences, became the seat of perpetual winter. Universal sterility ensued, and animal life, prompted alike by instinct and necessity,

retreated from a harsh and ungenial climate. Thus the North, as in modern times, retained only those creatures which, like bears and reindeer, could subsist on the slender nutriment of the Arctic flora, or which preyed on feebler and more gentle animals. The hippopotamus sought a refuge in the bays and rivers of England, and the lion and panther, as then represented, found in the caves of the Hartz mountains, or the impenetrable forests of Germany and Italy, a safe and inviting retreat. The change of temperature and physical condition operated so prejudicially on many species, that they passed completely away, leaving only fragile and imperfect remains, like half-erased characters, to mark their epitaph on the tomb of Time. But the mammoth yet lingered in the ice-bound solitudes of Asiatic Russia, or prowled over the wilds of Northern Europe. The carcase of one of these stupendous creatures, in a singular state of preservation, was found recently in Siberia in a bed of ice, supposed to have been formed entirely of drift-snow, which, driving with the force of an ava-

lanche, had overwhelmed the monster in its descent, and then piled a mountain above. We learn from a work called "Revelations of Siberia," recently published, and to which I shall hereafter have occasion to refer, that the snow often drifts into these heaps, whirling round in a spiral mass, like a water-spout. Sir Charles Lyell observes, that where the snow-drifts occur, it may sometimes happen, that cattle grazing near rivers may be swept away, and be transported, imbedded in ice, to the polar regions, where they may find a mausoleum like that of the mammoth, in the frozen depths of the North.

Looking at the great extent of territory redeemed from the ocean during the three tertiary periods, it is natural to expect, on a first glance, that we should be able to trace the landmarks of the system with perfect ease, and find numberless monuments of its history. And it does undoubtedly yield a great number of fossils, though, comparatively speaking, very few, considering the lateness of the era, are terrestrial, and, among the animal reliquia,

fewer still are remains of mammalia. Geologists have discovered innumerable species of Zoophyta and Enchinodermata, members of the shell family, with a great variety of reptiles and fragments of fish, where scarcely one mammiferous relic has been brought to light; and in the same way, the flora also is chiefly marine. Still the tertiary catacombs embalm in their sands and clays precious vestiges of terrestrial creation; and among them we find several species of the elephantine genus, with tigers, wolves, hogs, deer, opossums, monkeys, and other land animals, some of which belong to species now extinct. Birds appear, but in no force, and but little variety. Few of the countless mollusca, of which so many species have been discovered, are represented by living genera; and the family of reptiles also present wide marks of distinction. Of the plants of the era, the greater part, as already remarked, are aquatic, but the terrestrial species brought to light indicate a vegetation very similar to our own. So close, indeed, is the resemblance, that naturalists, in examining the later tertiary

formations, can scarcely detect a difference, as the species can only be ascertained by certain internal marks, not easily recognized. These, when the cellular fabric has not perished, are the dots on the vesicles; but it frequently happens that only the elementary fibre remains, and the difficulty of fixing the species is then greatly increased. In some cases, however, the genus is easily recognized, and the fruit of a particular kind of palm, now indigenous to the Philippine Islands, and of another confined to Japan, has been found in the tertiaries of the Isle of Sheppy, as well as some cocoa-nuts, melons, and gourds, which, while they attest the fertility of the soil, indicate a very different climate from that of the present day.

Among the animal fossils of the tertiaries, we find one suggestive of an incident of our own times, which indeed invests it with peculiar interest. This is the Palæophis-typhæus, a marine serpent, measuring upwards of twenty feet in length, and an undoubted inhabitant of the British seas. Several other species of Serpentia have been discovered, one of which,

allied to the Boa family, is of gigantic dimensions. A monster tortoise, measuring twenty feet across the back, has been dug out of the freshwater tertiaries of India, and, in the same deposits, a giraffe and camel represent the animals of the existing creation. The Sivatherium, Mastodon, and Deinotherium, as well as the Palæotherium and Anoplotherium, huge and unwieldy quadrupeds, connecting the elephantine and tapir families, are seen prominently in the Eocene rocks, but gradually disappear. The tapir is the nearest living representative of these races, and is found in the Indian Archipelago and South America.

The tertiary strata are of comparatively modern date, but the time occupied by their deposition, if the evidence they furnish may be relied on, is absolutely incalculable. The whole of the eighty cones of Etna are supposed to have been thrown up in the latter part of this period; and it is conceived, from the texture and fabric of their rocks, that at least twenty thousand years must have elapsed between the eruption of the first and last

cone. Only one, Mount Rossi, has been erected during the historic era.

Over the tertiary strata, time has accumulated a heap of diluvial and alluvial deposits, which, in the promiscuous character of their sediment, tell a strange tale of convulsion and disorder. It would seem that the earth was now subjected to some tremendous catastrophe, which entirely deranged the order of nature. What was the precise character of this visitation cannot be ascertained; but it is universally admitted, by geologists of every class, that there are unequivocal indications of the action of water. Enormous boulders have been wrenched from their beds, and carried over mountain ridges into other regions; masses of rock have been torn from the rugged heights of Scandinavia, and swept across the sea to Yorkshire and Cumberland; even the Alps have formed no barrier to the swollen tide, and the green valleys of Switzerland are strewn with fragments of St. Bernard.

The organic remains of the deposit include, in various heaps, relics of almost every type now

in existence; and, strange to say, many animals of the most opposite tendencies, utterly inimical to each other, are found lying together in caves and natural fissures, which barely afford space for the crowd of inmates. Thus we have elephants, lions, tigers, panthers, wolves, horses, oxen, deer, monkeys, snakes, and lastly, for the first time, MAN, occupying without hostility one and the same retreat.

Philosophers have been unable to account for appearances so completely at variance with the fundamental laws of nature; and invention has been exhausted in attempts to devise a satisfactory explanation. Some assert that the diluvium is the result of an inundation of mud, which, rising to a great height, and driven by a resistless impulse, possessed sufficient force to bear away with it the numerous erratic blocks, and transport them to enormous distances. It is contended, however, by others, that both boulders and gravel have been dispersed by icebergs, which brought them round from the Arctic regions, and deposited them wherever they happened to thaw; while not a

few maintain that the entire formation has indisputably been deposited by water, though they allege that the earth could not have been universally submerged except by displacement from its axis.

On the other hand, those who favour the theory of a cataclysm, as coinciding alike with Scripture and tradition, consider that it might have been occasioned by the sudden elevation of mountain chains, which would displace a great body of water, and necessarily drive it over the adjacent territories. But the Alps and the Pyrenees, the Andes and the Himmalaya, whose snow-crowned heights are more especially referred to, had, if the chronology of their strata is to be credited, been long previously in existence; and even had their elevation been actually co-eval, the displacement it effected would not have been terrestrial, but atmospheric. Nor does the supposition of the uplifting of a vast shoal, which would drive an immense volume of water from its customary basin, and by raising the level of the ocean, pour a flood over the land, seem more

reasonable or probable. In fact, though the evidence of a great convulsion presents itself at every point, Science is baffled in her efforts to trace it to natural causes.

But a fresh dispensation—a new covenant of being, was now established, never again to be infringed. The raging waters, which had swept over every barrier, were rolled back to their depths, subdued and powerless. From the summit of Ararat, a single family gazed down on the expanse, and though preserved from the past, looked with dread solicitude to the future. Then it was that, in the silence of that mighty solitude, they heard the reassuring voice of God, proclaiming that henceforth seed-time and harvest should never fail: and as the smoke rose slowly from the atoning sacrifice, piled on its homely altar of stones, the beauteous rainbow spread its brilliant hues on the sky, a pledge to remotest generations that "all flesh shall not be cut off any more by the waters of a flood, neither shall there any more be a flood to destroy the earth."

V.

THE TWO REVELATIONS.

THE earth has risen from the bottomless grave of the Past to divulge the long story of her existence. We hear and wonder, and the delusions in which we have been reared, with so much mistaken and misguided piety, vanish like smoke before the flame. We thought to behold the Creator reflected in His works; but, blinded by Rabbinical traditions, could only see Him as in a glass, darkly: now the veil is removed, and we stand before Him face to face.

At first, the mind, measuring all things by its own capacity, reels under an impression so

awful, and, like the Prophet on the Mount, shrouds itself from the presence of God. But we need not fear. The Being we behold, though more fully revealed, is no new Deity. It is the same voice speaks that talked with Adam in the garden, and called to Moses from the burning bush. From the moment we receive this conviction, our thoughts, instead of being paralyzed with terror, acquire a reverent confidence, and eagerly recal the accents of inspiration. Looking back to the early ages of the world, they discern a lapse that, to human comprehension, indeed appears endless, but which is less than a breath in the sight of the Almighty. They seem to contemplate Eternity, and learn that it is only Time.

Time, then, is immeasurable. The light that gleams upon us, with feeble lustre, from the immovable stars of Heaven, has been thousands of years on its way. Some of the formations which constitute the crust of the earth, to a depth of many fathoms, are composed merely of the remains of animalculæ, which must have been millions of years accumulating.

To mention an example, Tripoli stone is formed of exquisite little shells, so minute and so numberless, that a cube of one-tenth of an inch is said to contain 500,000,000 of individuals. The chalk beds have accumulated from the excrement of fish; and the Numilitic limestone, which has furnished the imperishable blocks of the pyramids of Egypt, is a concretion of small shells, chambered with the most perfect symmetry, and deposited in the course of innumerable ages. What is it, then, to say, in the devout words of the Psalmist, that a thousand years are esteemed by the Deity as but one day? In comparison with the vast periods of geological time, a thousand years are as nothing!

The soul feels cheered and elevated by this sublime discovery. Our perceptions of eternity, which hitherto has seemed an enigma, become more definite, and, standing on the platform of the past, we are enabled to appreciate the duration of the future. We look at the fabric of the earth, and the stupendous architecture of the skies, and learn, with deep and solemn joy,

that they are not the work of yesterday, but have existed from a period beyond comprehension. The divine image of the Creator shines forth with increased effulgence, and we see more clearly, in its universal presence, the majesty and infinity of His attributes. How marvellously are they displayed in the Heavens, beyond what the mind can fathom or the imagination conceive, making the clouds his chariot, and the furious winds, which seem to fly masterless through the air, his messengers. With what wonder do we find them manifested in the secret depths of the earth, where successive creations, swept from the face of nature, have sunk into everlasting rest! Design seemed exhausted in the endless variety of existing races, but the book of nature, unfolding its tablets of stone, discloses myriads of other creatures, all exhibiting equal diversity of form and aspect. The end of each world of beings, defined by the rocks in which they are deposited, is but the frontier of one anterior, and life, instead of being a modern novelty, extends back so far, that it is impossible to say where it disappears.

One thing, however, is always apparent, and that is, the directing and over-ruling power of a tutelary Providence.

But while the extreme antiquity of the earth must be received as an absolute and incontestable fact, it is no less certain, that man, its present sovereign, is a creation of comparatively recent date. After tracking him backward for nearly forty centuries, we lose the traces of his presence in the massive ruins of Nineveh. Here, almost as the waters of the Flood subsided, his industry and genius were again active, and employed themselves in the erection of structures which should endure for all time. The cities and edifices of the earlier world, built, perhaps, with little regard to solidity, had left not a fragment behind, but here we find walls of adamantine strength, designed to resist the mightiest shocks. As if warned by the catastrophe of the past, the new generation recorded their history, not in archives liable to perish, but on walls of granite, to convey the wild tale to latest posterity. Languages might pass away, but Time, with all its changes,

could not destroy the identity of sounds, and, adopting this medium of perpetuating their annals, they trusted to human invention to discover a key to the mystery. Egypt, wandering to another soil, carried away the same tradition of instability, and the hieroglyphics of Thebes and Memphis were suggested by the characters of the sons of Asshur.

The first vestige of man is a colossal city, laid out with mathematical precision, and exhibiting an extensive knowledge of the arts. Gorgeous palaces and stately temples, adorned with imposing columns, which support the light and graceful arch, are among the wonders of this entombed capital; and conduits and gigantic statues still further attest its magnificence. Its Kings were attended by mighty armies, and surrounded by all the accessories of barbaric pomp. Priests thronged its courts; and the worship of the one true God, still preached in its purity by Noah, was disguised in myths, or superseded by that of Dagon and Baal. The cruelty of man kept pace with his civilization, and the mild sway of patriarchial government,

which prevailed among pastoral communities even so late as the time of Abraham, vesting the head of a family with the prerogatives of a King, was exchanged for the terrors of Asiatic despotism. Dungeons were excavated in the bowels of the earth, and miserable captives were butchered in secret, or impaled alive on the ramparts of the city.

But the colossal masonry which, in the imagination of its founders, was to defy the waters of another flood, was swept away by an inundation of the Tigris. Long before, the arrogant inhabitants of "the city of blood" had been apprised of their fate: "With *an overruning flood*," cried the prophet, "God will make an utter end of the place thereof, and darkness shall pursue his enemies. *The gates of the river shall be opened*, and the palace shall be dissolved." In fulfilment of this prophecy, Cyrus, with an army of Medes, flushed with recent victory, was knocking at the gates, when thirty furlongs of the wall were washed down by the river, and the conquering host marched unopposed into the city. Learning what had

occurred, the King, in a fit of despair, fired his palace with his own hands, and perished in the flames. "The fire," exclaimed the prophet, "shall devour thy bars; then shall the fire devour thee." And the total destruction of the city is foretold in the most emphatic manner, "The Lord hath given a command concerning thee, that no more of thy name shall be sown: I will make thy grave, for thou art vile."

Between such a state of things as existed at Nineveh, and the last relics of geological time, there is a wide and seemingly impassable gulf. The earlier creations, with their strange and marvellous races, are swept completely away, and the world is peopled by a new order of beings, at best represented very feebly before. The forests no longer afford a haunt to the prodigious mammoth, or the frightful labyrinthodon; no flying reptile, like the dragon of fable, lords it equally over the land, the ocean, and the air; and no hideous monsters wade along the shores, or battle in the depths of the sea. Yet the variety of form and condition, which seems to characterise every previous aspect of nature

as far as the researches of geologists extend, is no less grand and decisive. To add majesty to the new creation, it is headed by MAN, a rational and accountable being, distinct from all others, and endowed with faculties connecting him immediately with the Creator.

Where are we to look for an explanation of this gap in Time, this wondrous transformation of nature? We turn over the tablets of the earth, on which its earlier annals are recorded, without gaining a clue to the enigma, and search in vain among the ruins of primeval worlds for the first footsteps of man. We learn indeed a sublime and precious lesson, but it is of the eternity, the infinity, and the omnipresence of God. We behold creatures of every shape and size, adapted, by habit and instinct, to every grade of existence, but find no remnant of the divine form of the lord and master of all. The historic rocks proclaim that the world was yet strange to the beautiful conceptions of his mind, the achievements of his art, and the contrivances and fruits of his industry, his intelligence, and his labour. Garden it might

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be, but the halo of intellect was required to constitute an Eden.

At this point we should pause, in a maze of perplexity and doubt, but what we miss in science is supplied by religion. Thus we possess Two Revelations, which confirm and establish each other: one, the terrestrial, is interpreted by geology; the other, written by Moses, is dictated by inspiration, and claims to be regarded as the Word of God.

It is not surprising that, at first sight, these chronicles should seem to record facts at variance with each other, and which it is difficult to reconcile. The contradictions, however, are but in appearance, and vanish before the eye of inquiry. "The Two Revelations" are perfectly distinct, and when viewed together, should be considered with a clear perception and recognition of the individual purpose of each. The Mosaic narrative, for instance, while describing the grand incidents of the creation, is less a history than a religious exercise, apprising us that all things had a beginning, and that that beginning was with God. It shows us our

origin and our mission, and points out, in precise and unmistakeable terms, the debt of worship, obedience, and service which we owe to our Maker. The work of creation receives but a cursory glance, just to set forth the supremacy of its Author; but the history of man, to whom it is addressed, is related at large, and the various epochs of his career are faithfully and carefully noted. In short, the account given by Moses is a lesson, not in science, but in religion, appealing by its simple dignity to the understanding of the ignorant and foolish, while it carries conviction to the minds of the enlightened and the wise.

Very different are the aim and tendency of the occult revelation of geology, and, indeed, of science generally. Here man finds a field of investigation as fruitful as it is unbounded, opening fresh treasures at every step. From Holy Writ he learns, by a direct communication from Heaven, that he is the appointed lord and heir of all things: the volume of nature teaches that he is less than an atom in the vast circle of creation. Instructed in all that concerns his

moral and religious government, he is invited, by the beauty and peculiar character of every object, to contemplate the mechanism of the whole universe, and explore its remotest and most secret recesses. In this pursuit an employment is provided for the great faculties with which he is endowed, and which make him who was created a little lower than the angels, their fellow and equal. By such means only could he be brought, through the sublime medium of reason, to understand the superiority and dignity of his position, and the majesty and beneficence of his gracious and omnipotent Maker.

Nor should it be forgotten, in considering the character of the divine record, that Moses, though writing under inspiration, was probably himself ignorant of the precise meaning of his statements. Indeed, he has imparted to them a colouring which goes far to establish this fact, and which is evidently derived from his Egyptian tutors. It is a miraculous circumstance that the bias of the sacred historian does not impair the authority of the narrative,

nor commit it to views which are really opposed to the disclosures of science. We can imagine that, with his previous training in the fallacies of Egyptian philosophy, which was based on the testimony of external appearances, and, consequently, confirmed by the senses, his mind would have been unable to comprehend the true economy of the universe, even had it been revealed to him; and, if the prophet were confounded, what faith could have been expected from the common people? How would the Israelites have mocked had they been told that it was not the sun that moved, but the world; that the moon, whose soft lustre illumined both Heaven and earth, was like our own globe, a black opaque body, traversed by chains of mountains, and broken into plains and valleys; and, finally, that the countless stars above were so many suns, the centres of other systems. Nor was it needful that they should possess this information, which it had been ordained by God from the beginning should be acquired by our own researches. The object of the historian was simply to relate the origin

and course of the creation, and while no principle of physical science was negatived, it was permitted by the Deity, with equal wisdom and forbearance, that the narrative should bear a construction acceptable to a people naturally hard of belief, and deeply tainted with the superstitions of paganism.

Probably it was to attract their minds from the lures of idolatry, as well as to foreshadow a future and more merciful dispensation, that the laws propagated from Sinai enjoined a ceremonial of so gorgeous and elaborate a character, and which was calculated to impress them at once with awe and devotion. And we find throughout the Bible, that it was customary with the prophets to clothe their religious admonitions in myths and fables, as if to enchain that passion for mystery which the people had acquired from their heathen neighbours. Thus Moses describes the fall of our first parents, disguising, in a simple but sublime apologue, the nature of the dreadful trespass they committed. Nathan, under the immediate inspiration of heaven, appealed to the sleeping

conscience of David in the touching story of the pet lamb, in which he demanded vengeance for the blood of Uriah. The book of Ezekiel abounds with allegorical images, addressed to the same spirit of mysticism, and, to mention a more memorable example, our blessed Lord himself, in his forcible and beautiful parables, employs a similar machinery to engage the sympathies of his hearers.

This frequent adoption of metaphor should never be lost sight of in studying the Mosaic narrative, as there can be little doubt, in any rational and unprejudiced mind, that the term "day" in the account of the Creation, like that of "week" in the book of Ezra, represents a period of far greater duration. At first sight, indeed, this would seem to be directly opposed to the fact; for it is distinctly stated, as if in anticipation of such a construction, that "the morning and the evening were the first day." But the Oriental versions of the Bible give the passage in a different manner; and from them we learn, what is more consonant with the disclosures of science, that "there

were mornings and evenings, a first day," indicating, in fact, that the term is used to mark a long interval, which embraced mornings and evenings without number.

Admitting, however, that it is to be interpreted in its most limited signification, we are not called upon to believe that the six days appropriated to the Creation were *consecutive* days, and, for all that appears to the contrary, vast periods may have elapsed between each. Nor would this circumstance, if properly and religiously considered, at all detract from the glory and greatness of the Creator, or set any limit to His unbounded power. With Him, to will is to do, and He holds all things in the palm of His hand. Except to accomplish a wise and inscrutable purpose, it was not necessary, in the exercise of His almighty attributes, to devote six days to the work of Creation: six minutes—a single second, had been ample time for its completion. But it is the pleasure of the Deity to operate through the interposition of specific laws, which, while they act with unerring precision, only fulfil their end in the

course of countless ages. And it is, as I have before remarked, the mechanism of His works, as much as their grandeur and sublimity, that excites our wonder and adoration.

The Mosaic chronology commences with the creation of man. The date of the BEGINNING, which some include in its range, is not indicated. We are simply told that, "*in the beginning* God created the Heavens and the Earth." No time is mentioned, but it would seem, from the context, and the order in which the statements appear, that after the lapse of a considerable period, some great change was effected in the condition of our globe. Other alterations, indeed, of a character equally decided, may have occurred previously, and we now know that such was the case; but only one is particularly mentioned, because it is that which immediately preceded the existing Creation. The derangement produced, whatever it might be, was not confined to the earth, but extended to the whole of the solar system. The sun, the moon, and the stars—by which we are to understand, not the entire circle of the heavenly bodies, which

are described in Scripture as "the host of Heaven," but only the *planets*—were all subjected to the same convulsion. The earth was without form and void—that is, the incessant elevations and depressions of the surface, consequent on internal commotion, left its form undefined, and nature desolate, although, as a matter of necessity, it retained its figure of an ellipsoid of revolution, by which it was held in its orbit, and continued to revolve round its centre of gravity. Darkness was on the face of the deep, because the sun, the great source of light, no longer gladdened the skies with his radiance, and the deranged atmosphere shut out the feeble rays of all other orbs. The sun was still obscured when the voice of the Deity exclaimed "Let there be light!" By what means the luminous effect was produced, it would be idle to conjecture, but science has taught us, among other wondrous and mysterious truths, that the sun, supreme as it undoubtedly is, is not the only source of light, and, familiar as we are with the extraordinary appearances produced by refraction, and the dazzling efful-

gence of the Aurora Borealis, we can see no difficulty in attributing the light described by Moses to some natural phenomenon. The Jewish law-giver, trained in the philosophy of the ancients, which held the sun to be the sole distributor both of light and heat, was necessarily unacquainted with this fact; and, had he been prompted only by the traditions of men, would doubtless have recorded the creation of the sun as anterior to that of light. Thus the seeming inconsistencies of his narrative are a testimony to its truthfulness and authority. The sun, indeed, was soon to burst forth with sublime majesty, to enliven, exhilarate, and beautify the restored earth. The prodigious mass that had lain so long, like a blot, on the darkened sky, was now enveloped with a luminous atmosphere, which spread light and joy over the whole Heavens. At the same time, the moon, which had participated in the general disorganization, was re-constructed, and resumed its majestic functions, Thus, "God made two great lights: the greater light to rule the day, and the lesser light to rule the

night;" and though, strictly speaking, the moon is not in itself a light, but a reflector, yet it does undoubtedly serve as a luminary to the earth, and, therefore, may justly be called one. Meanwhile, the atmosphere, or, as it is rendered by our translators, the firmament—literally, *expansion*—was relieved of the deadly exhalations with which, in the universal convulsion, it had become so largely impregnated, and the earth was surrounded by successive strata of air, free from every noxious particle. By some process of nature, evaporization was effected, and the waters exhaled from the globe, previously almost submerged, were raised above the firmament—that is, condensed into clouds—and separated from those that were under the firmament. This operation was probably conducted on a scale surpassing any experience of man, as the immense expanse of water, occupying nearly the whole extent of the earth, was peculiarly susceptible to evaporization, and there can be no doubt that the medium employed was one of extraordinary power. The result was, that

the land, of which only mountain chains or tracts of gloomy swamp had previously been visible, was redeemed from the waves, and the sea driven back to its natural boundaries.

The same agent which acted as a source of light, and a means of evaporization, necessarily imparted heat, which, in fact, is considered by philosophers to be only another form of the luminous fluid, and has even been called *obscure light*. We may conclude, indeed, that a temperature existed far exceeding that which depends on the sun, and that this was one reason why the great centre of gravitation, the natural means of action, was still permitted to remain a dreary and naked blank. Its heat would have been insufficient, without some miraculous interposition, to draw out the latent virtues of the earth, and, therefore, another agent was substituted, which, as fertility returned, gradually fell back on the sun, and clothed its mighty heights with flame. The earth had "brought forth grass, and herbs yielding seed after his kind, and the tree yielding fruit, whose seed was in itself, after

his kind, and God saw that it was good." The equilibrium of nature was restored, and now, approved and blessed by the Deity, she might safely be left to the government of her own everlasting laws.

It is singular, when so much attention has been directed to the first chapter of Genesis, that the manner in which the creation of both plants and animals is described, has hitherto escaped particular remark; for the record, though brief, bears a very significant import. We are told that God said: "Let the earth bring forth grass; the herb yielding seed, and the fruit tree yielding fruit, AFTER HIS KIND, whose seed is in itself, upon the earth: and it was so." And again, God said: "Let the earth bring forth the living creature AFTER HIS KIND; cattle, and creeping thing, and beast of the earth, AFTER HIS KIND: and it was so."

Such declarations seem to intimate, with less obscurity than one might expect (remembering that Moses addressed a people immersed in ignorance and barbarism), that there had been an anterior creation; and that it was no new

thing for the earth to bring forth trees yielding fruit, whose seed was in itself AFTER THEIR KIND, or for living creatures, called into existence by the divine fiat, to increase and multiply upon the earth, AFTER THEIR KIND. It is true that, in a subsequent chapter, the sacred historian expressly states that the vegetation did not spring spontaneously from the ground as the natural produce of the soil, but was a specific creation of God, when, "as yet, there was none of them;" and we are undoubtedly to believe, as a fact established both by Scripture and Geology, that our present botanical products are peculiar to the existing condition of the world. But while they do indisputably belong to a new and distinct creation, it is equally true, that the earth had previously brought forth "the herb yielding seed, and the tree yielding fruit, whose seed was in itself, after their kind," although, as their remains testify, they were of a different character and structure. The same explanation applies to the creation of animals, which, though in some cases approaching very nearly

to pre-Adamite races, are nowhere actually referable to the same species, and, consequently, mark an entirely new epoch in the condition of being.

More than two thousand years elapsed before the world was again subjected to any signal derangement. It was for a long time supposed, from the general tenor of the facts, that this derangement was universal, and of a similar character to those terrific convulsions which, as we learn from geology, have frequently overtaken our planet, and might almost be considered periodical. But such a conclusion would seem to be unfounded, and is by no means authorized by the language of Holy Writ. All philosophers agree, that the Deluge extended over the whole territory occupied by man, and left but one family alive to relate the catalogue of its horrors. But it should be borne in mind, that man then inhabited only a section of the earth, and therefore, that the Flood, though it ingulfed the entire race, might easily have been confined to a single continent. The object of this visita-

tion was to destroy man; for all flesh—that is, the whole human race—had become corrupt on the face of the earth, and it repented God that he had made man. Nor are we justified in giving too wide a significance to the expressions used by Moses. The phrase of "under the whole heaven," which in this case is thought to be decisive, is not more emphatic than the terms used frequently in the Scriptures to denote only a portion of the globe, and that of limited extent. Even St. Luke, who was not only an inspired Evangelist, but a scholar, versed in all the knowledge of his time, describes the memorable Feast of Pentecost at Jerusalem, as being attended by strangers from every part throughout the world. But St. Peter shows clearly what range we are to give to the Mosaic description, when he tells the Churches of Asia, in his eloquent and emphatic epistle, that the Flood was sent to destroy *the world of the ungodly*—in fact, those regions inhabited by man.

It has been deemed conclusive of the com-

pleteness of the Deluge, by those who support that view, that a tradition of a cataclysm prevails universally among mankind, so that even the most savage tribes afford corroborative testimony to the record of Moses. But this proves only that the Flood ingulfed the entire human family, and that the races now existing, however different in external appearance, not only sprang originally from one stock, but spread over the world from one point. On their dispersion, they naturally carried away with them a tradition of that memorable catastrophe, which has thus become localized in every region.

But while admitting that a universal Deluge appears unlikely, as being, so far as we are able to judge, more than the purpose in view required, it must at the same time be acknowledged, that the arguments advanced to disprove its universality, as a physical impossibility, are far from conclusive. It is idle to say that the submersion of the globe would displace it from its axis; for, if we suppose the Deluge to have occurred at all, we must believe that

it arose from a derangement of the ordinary laws of nature, and, therefore, through a direct interposition of the Deity; and special circumstances being recognized in the incident, must be allowed also in the effect. More weight attaches to the discovery that a chain of conical hills in France, identified as the craters of extinct volcanoes, are still strewn at their summits with volcanic ashes, the product of eruptions anterior to the Flood, and which, had the submersion been universal, must have been washed away by its waters. But it is no argument to urge that, in the ordinary course of nature, each of this cluster of peaks would require two thousand years for its development, aad hence to conclude that some account of their elevation would have been preserved, had it occurred subsequently to the Deluge. The conjecture may be correct as far as relates to a general principle; but nature, though her operations are for the most part uniform, is sometimes strangely inconsistent, and the Deluge itself could only have resulted from a complete overthrow of her equilibrium. We can easily imagine, too, that

the great catastrophe was followed by extensive changes in the configuration of the land, principally effected by volcanic action. To drive the waters back to the depths, and raise the level of the land, volcanoes may have been thrown up in a single century, which, in the usual course of events, would only have been elevated in myriads of ages. And even supposing that no more than one of the peaks is post-diluvian, the eruption of a single crater would be sufficient, without any separate action, to strew the whole chain with volcanic matter.

Nevertheless, it is certainly a singular circumstance that no similar vestige has been found in the East, but that, on the contrary, the statements of the sacred record, that "the waters prevailed exceedingly," and that "the tops of the highest hills were covered," are fully borne out by the character of the soil. From a letter in a recent number of the *Athenæum*, it appears that the plain of Thibet, which is at an elevation of 15,000 feet above the level of the sea, is a post-tertiary formation, and, as it has rendered up bones of the elephant and hippopotamus,

must have accumulated in comparatively recent times. Thus we see that some of the highest ground in the world was at no distant period covered by the ocean, and yet incloses in its crust the remains of animals essentially terrestrial. It cannot be doubted, therefore, that we behold on this spot incontestable traces of the presence of the Deluge.

The boulder formation, to which I have referred at large in the preceding chapter, is no longer considered a diluvial deposit; and probably a recantation endorsed by the distinguished names of Buckland and Sedgwick, ministers alike of religion and science, will leave few minds obdurate in the old delusion. At the same time, it cannot be denied, by any dispassionate judge, that the dispersion of the erratic blocks is very unsatisfactorily explained by the glacial theory, which, however subtle and elaborate, fails to induce conviction. Abandoning the supposition of diluvial agency, we are forced to the conclusion that, at some earlier period, the earth was the theatre of a terrific and uni-

versal convulsion, the precise character of which we are utterly unable to comprehend.

The strongest argument against the universality of the Deluge is furnished by the dimensions of the ark, which Moses, apparently to guard against misconception, has set down with the greatest precision. In describing the Flood, he uses general terms, possibly taking that poetic latitude so popular among Oriental nations, and which, after an interval of 4,000 years, is still the household language of the East. The same spirit pervades his account of the animals collected by Noah, but in recording the dimensions of the ark, in which they were all to find refuge, he indicates clearly the precise sense in which his expressions are to be received. If we suppose those creatures only to have been preserved which were useful to man, or necessary to carry on the functions of nature, as far as they ministered, by their operation and effect, to man's wants and comfort, then the ark might easily have afforded room for the favoured seven couples of

each species. And if we add to this extensive assembly the families of Noah and his sons, and the provisions required for the sustenance of all, and which—a convincing proof that no miracle was intended—Noah was directed to stow in the ark, we shall find the whole space fully occupied. Nor is it easy to conceive that man would be enjoined, not only to preserve, but himself to associate with wild and rapacious beasts, and venomous reptiles, which every instinct urges him to destroy, although, in point of fact, they have each their special place in the beautiful economy of nature, and are all designed in the same spirit of wisdom and mercy.

But the difficulty presented by the dimensions of the ark, though certainly serious, is not absolutely insurmountable: and, should the universality of the Deluge be insisted upon, we must conclude that the measurement given by Moses is merely symbolical, and that the great repository of life was really far more capacious. How so unwieldy a body could be sustained on the waters, is a question we are not called upon to

examine. Guarded by the divine hand, it rode calmly and steadily on the flood, while the subversion of nature was complete—a floating Goshen, safe amidst destruction.

The ossiferous caves found in so many parts of the world, and to which I have before alluded, may, I think, be regarded as unquestionable vestiges of the Deluge, showing the submersion of, at least, the greater part of the land. These gloomy recesses are packed with animals of every kind, which, as the waters rose upon the earth, here sought a common shelter. It is well known that, in the presence of great natural convulsions, the most untamable beasts quite lose their native ferocity, and the tiger and lion herd in peace with the lamb. But how Man, so widely separated from all, could seek a retreat in such a den of monsters, does indeed baffle comprehension. How must he have striven with his terrors, ere, climbing the rugged steeps of the ravine, he threw himself into this horrible refuge. But even here there was no hope of escape. The rain still descended: the flood,

fed by a thousand roaring torrents, rose higher and higher, and, at length, rushed furiously into the cave, while its voice of thunder stifled the cry that rose, at the same moment, from man and beast.

VI.

NATURAL FORCES AND PHENOMENA.

One of the most fascinating problems on the Sybilline leaves of Science, refers to the structure and economy of the earth, from the dust of which we sprung, and to whose capacious womb, when the struggle of life is over, we must all return. While we contemplate with wonder and awe the starlit sphere of Heaven, where universe balances universe, and the Creation parades its grand and mysterious details, a mechanism equally sublime and no less startling is in constant operation in our own planet, and partly under our own eyes. The Earth, our ever-fruitful mother, is enve-

loped in an atmosphere of marvels; her bosom heaves with prodigious emotions; her heart is the prey of unquenchable flames.

This stupendous orb is supposed by philosophers to have been thrown off by the sun, in a fluid mass, which, as the temperature diminished, gradually solidified. Its figure, as determined by a comparison of measurements in different latitudes, is an ellipsoid of revolution, with an equatorial radius of 3962·824 and a polar radius of 3940·580 miles. The entire circumference is 24·856, and the diameter nearly 8000 miles. This body has, according to the recent experiments of Reith, a density of 5·44 in excess of water; but as that of the surface does not exceed 1·6, it is obvious that, either from the peculiar character of the matter, or from condensation, the density is much greater towards the centre. Of what the centre is composed is indeed a problem, which baffles both science and conjecture, though it is sometimes urged, as a not unreasonable hypothesis, that the internal structure is cavernous, rising from a condensed mass, and supporting

a shell, or crust, of comparatively-superficial depth, on which we tread. This causeway, resting on these mighty arches, is formed of stratified rocks, the only masonry that can vanquish time; yet the basement of its pillars, down in the centre of the earth, is, from internal heat, reduced to fluid, converting the depths below into an unfathomable cauldron.

The magnetic force varies in intensity in different latitudes, attaining its maximum at four remote distances, which, from the peculiar action, correspond neither with the magnetic nor the rotatory poles. The exact character of the force is unknown; but its influence, which is regulated by the sun, by subterraneous galvanic currents, and by variations of terrestrial temperature, is universal. There are two points of maximum intensity in each hemisphere, those in the northern regions being, according to the best computations, about 120° east longitude in Siberia, and the other near Hudson's Bay; and those in the opposite hemisphere, by the testimony of the same authorities, at different

points in the South Atlantic. The maximum intensity for the entire surface of the globe is 2·052, and the minimum 0·706.

In addition to the phenomenon of varying intensity, the magnetic power distributed over the surface of the earth, in the manner described, exhibits itself in two other forms, the tendency of the inclination, and the horizontal deviation from the terrestrial meridian. All three phenomena are measured and ascertained by two simple instruments—the mariner's compass, and the dipping needle. One end of the magnet, or declination needle, points unerringly to the north, and the other end to the south; and in the northern hemisphere, the north end has a motion from east to west, while, in the southern, its motion is from west to east. The dip of the needle, as it is generally called, ceases at a certain point, where the earth is traversed by the magnetic equator, which, like the terrestrial, divides the two hemispheres, though with less precision; and in this region the needle has no dip, but is always horizontal.

Magnetic storms, which arise without the least warning, greatly disturb the horary motion of the magnetic needle, and are felt simultaneously in different quarters, extending themselves, after a brief interval, over the whole surface of the globe. Whence they arise has long been a puzzle to the learned; and, after the closest observation, philosophers are unable to decide, with any certainty, whether the disturbing influence resides in the Cimmerian caverns of the earth, or in the atmosphere. At the same time, it is unquestionable that they are sometimes connected with electricity, since the affinities of that force with magnetism, long suspected by adepts, have now been placed beyond dispute, and, in fact, constitute the key to electro-magnetism.

The magnetic compass, one of the most precious of human inventions, is the charmed gift of magnetism. Without this faithful pilot, we could neither make direct roads by land, nor direct our course by sea. The power of the magnet for this purpose appears to have been known to man from time immemorial;

and it was in use among the Chinese, if their boastful traditions may be believed, in the earliest ages, though not introduced into Europe till the era of the Crusades. Nor was its universal adoption by mariners, as an indispensable item of their equipment, followed speedily by any increased knowledge of its properties, several centuries having elapsed before its variation was discovered by Columbus, who, in his first voyage, noticed, as he progressed, that the hitherto-steadfast needle declined from the meridian. What must have been the reflections of the daring navigator, when, in that unknown and pathless sea, never before invaded by the keel of a ship, he thus saw himself forsaken by his only guide! In what could he place his trust, when even the magnet swerved from the pole?

Magnetism, as already observed, is intimately connected with electricity, a fact established by Oersted so late as 1820. Like the sister influence, electricity baffles analysis, but is supposed to be a modification of ether, the thin, subtle element which fills the bounds of

space. Electricity pervades the earth, and all substances, as well as the atmosphere, but seldom penetrates beyond the surface. The intensity is greatest when the form of the body is circular, and a sphere, round which the surface is spread in equal proportions, retains the electric fluid with the greatest facility. All bodies, however, are subject to it, though not in an equal degree, some offering considerable resistance; and the distinction is so great that one class is called conductors, and the other non-conductors.

Electricity may be either positive or negative: when bodies are, from any peculiarity of character, overcharged with the fluid, the electricity is positive; when imperfectly supplied, it is considered negative. Substances are mutually attracted and repelled by their relative quantity of electricity, and may transmit it, by contact, to each other, the greater force discharging itself into the less. Collision is attended by a shock, which, however, carries off the redundant electricity, and the portion retained becomes perfectly quiescent.

Electricity may be elicited by any cause which deranges molecular attraction, whether it be natural or artificial. Atmospheric electricity, the more unsearchable essence, is assumed to be produced by the evaporation of fluids charged with earthy or saline particles, and by the action of heat and chemical decomposition. Thus the ocean is a great source of electricity, and it has been observed, as a general result, that the electric equilibrium is most steadily maintained where the atmosphere canopies water. The islands of the main ocean serve as magnets for the electrified vapour, collecting round their lofty peaks the floating masses of the atmosphere, like a robe of state; and I have been unable to discern the gaunt outlines of St. Helena and Ascension, the two watch-towers of the Atlantic, from the incumbent heaps of cloud. Hence it is that islands are so frequently visited by violent storms, though this effect, however prevalent in certain latitudes, is by no means universal. During a sojourn of several months in Malta and Gozo, I do not remember a single storm, though sheet light-

ning, unattended by thunder, was a frequent occurrence, and there were two or three slight shocks of earthquake. Iceland, according to Humboldt, is scarcely ever subjected to storms, though thunder is occasionally heard in Spitzbergen.

Evaporation by heat draws from the surface of the ocean an immense volume of water, which, condensing above, takes the shape of hollow bubbles, inclosing a fluid lighter than air, hermetically sealed by electricity. These clouds, as we call them, are seized by currents of air, which keep them in constant motion through every part of the atmosphere. At the same time, the repulsive influence which, like all cognate electrified bodies, they exercise on each other, sustains them aloft, and prevents their dissolving in rain.

Clouds of a white-red and orange colour contain the greatest amount of positive electricity, and those of a grey hue are coated with the negative fluid. When masses thus oppositely charged, overcoming the repulsive influence, approach each other, the electric element ex-

plodes, and hence arise thunder and lightning. Lightning evolves in three distinct forms—zig-zag, sheet, and globular; and is so rapid and sudden in its motion as to render scrutiny impossible. A flash is said to fly more than three miles in an uninterrupted straight line; but it is not absolutely known whether the final direction of lightning is upward or downward. Zig-zag and sheet lightning, the least destructive, expire as they appear; but fire-balls are not so rapid in their flight, and may sometimes be traced for several seconds, though in this brief space of time they cover a vast and incredible distance.

The back-stroke of lightning will destroy a person at a distance of many miles from the point of the first discharge, though it does not always follow, as an inevitable consequence, that a person struck by lightning will be killed. A few years ago, my father, then advanced in life, was struck down by lightning, and after remaining a moment stunned on the ground, got up, and walked home. Fortunately he had been drenched in a violent shower of rain, and to

this circumstance he probably owed his life, water having a repulsive power, and so diverting the electric fluid from the body. The flash passed through his hat, which was perforated by two holes; and on one side, where the fluid probably escaped, the nap was entirely burnt off.

A reduction in the temperature of the air will cause the clouds, sustained in the atmosphere in the manner described, to fall below the point of saturation, when they become aqueous, and descend in rain. This sinks into the pores of the earth, passing through the sandy strata as through a filter, and halting on the clays, whence, impregnated with lime, oxide of iron, &c., acquired during its passage through the rocks, it is discharged in springs, which usually find their way to rivers.

Thus fed by subterraneous tributaries, charged with earthy substances, and themselves urged through a channel of unequal consistence, which yields up particles to the grinding force of the current, rivers become powerful agents in the transport and deposition of matter. The natural

drainage, too, by means of springs, constantly tends to waste the high land; and this sediment is borne by the rivers into hollows and valleys, which thus rise in altitude as the high ground wears away. The effect of rain therefore, in its ultimate result, is to change the level of the whole surface of the earth.

But the action of atmospheric precipitations is extremely slow, and the changes they produce are such, that it is not till after the lapse of ages that they make themselves apparent. Forces of a more violent character are in constant operation in the interior of the globe, and occasionally burst forth, at certain points of the surface, in the most terrific phenomena. The volcano and the earthquake—the furnace and foundry of nature—accomplish more in a few hours than rain can effect in millions of years. By their combined agency, excited by similar and contemporaneous causes, continents are elevated and depressed, mountain chains thrown up, lakes and estuaries excavated, and the ocean studded with rocks and islands. The imagination can picture nothing so awful as these

prodigious ebullitions. In the midst of Egyptian darkness, while lightning darts in forked flashes across the heavens, and peals of thunder, crashing above, are answered by subterraneous detonations, the volcano shoots up a towering column of flame and steam, and inundates the surrounding country with molten fire. The atmosphere is choked with ashes, which, falling at a distance of many miles, fill up valleys, and entomb cities.

The irruption at Sumbawa, in 1815, ejected ashes as far as Java, a distance of 300 miles, and clouded the air to such a degree, that the darkness at noon surpassed that of the darkest night. The change effected by this convulsion was beyond anything that tradition or history has recorded, and tends to show, in a definite and precise form, what may have been the extent of such operations in the early ages of the world. The ground was agitated over a circumference of more than 1000 miles. Ships sailed, with a good depth of water, over what had been dry land, and stranded where they had previously ploughed the sea. In many places the

land was upheaved to a considerable height; in others, depressed into hollows, or gashed with unsightly fissures. In short, the aspect of the whole region was totally changed.

But although volcanic eruptions are of periodic occurrence, and have probably been in operation at different times in every part of the globe; and although, moreover, they do produce great and marvellous transformations, we are not to apprehend that they ever endanger the order and stability of nature. The modifications which they effect in the elevation and configuration of land, and the distribution of water, are, after all, of slight value, when considered in relation to the magnitude and bulk of the earth; and were a chain of mountains to be suddenly thrown up to twice the height of the Andes, it is not to be supposed that they would derange equilibrium. The surface, and even the form of our planet, are continually altering, but only in obedience to the great laws of the Creation, which, in the midst of universal and perpetual change, preserve the harmony of every part.

Volcanoes will remain for centuries in a state of repose, and then, with little or no warning, become fearfully active. Vesuvius, restless in the early world, was so long quiescent, that it was considered extinct, when, about sixty years after the Christian era, it suddenly renewed its eruptions. Ten years afterwards came that tremendous convulsion, which brought upon Pompeii and Herculaneum, the Italian cities of the plain, the awful doom of Sodom and Gomorrah.

Although every part of the earth's surface is supposed to have been affected, at some time or other, by volcanic force, volcanoes are now only found in particular regions, which, from unknown causes, remain subject to their action. In Europe the centres of action are Iceland, Sicily, Naples, Stromboli, and the Archipelago. Within the last twelve years, a small island, such as abound in the Archipelago, was thrown up by volcanic action in the Mediterranean, in sight of an English man-of-war, and was actually taken possession of by the Captain on the part of the Crown. But scarcely had our flag been

planted on this ephemeral terrritory, so strangely upheaved from the waters, when the whole fabric disappeared; and, like the baseless thing it was, left not a fragment behind.

Volcanic action is excited by the internal heat of the earth, operating on its surface, and this, on attaining a certain temperature, relieves itself by eruption. When the outbreak occurs, a column of fire and cinders, mingled with dark clouds of steam, shoots up perpendicularly from the crater, to an appalling height, and a stream of fused minerals, better known as lava, pours in overwhelming torrents down the sides of the mountain. The metallic ingredients of this fiery deluge are lead, copper, iron, arsenic, and silenium. With these are mingled rocks rent asunder by the eruption, augite, felspar, leucite, mica, and sulphur. Aqueous vapours, too, ejected from the burning crater, impend for a long period over the apex of the cone, and then descend in torrents of rain, which, washing over beds of scoriæ, cover the surrounding country with a deposition of mud. This frequently sweeps away trees and houses, and

overwhelms villages, spreading devastation and ruin in every direction.

The "Polynesian," a local newspaper, thus describes a recent eruption in the Sandwich Islands: "By an accurate measurement of the enormous jet of glowing lava where it first broke forth on the side of Mauna Loa, it was ascertained to be 500 feet high. With a glass, the play of this jet at night was distinctly observed at a distance of 50 miles, and a more sublime sight can scarcely be imagined. A column of molten lava, glowing with the most intense heat, and projected into the air to a distance of 500 feet, was a sight so rare, and at the same time so awfully grand, as to excite the most lively feelings of awe and admiration. The diameter of this jet is supposed to be over 100 feet. In some places this river is a mile wide, and in others more contracted. At some points it filled up ravines of 100, 200, and 300 feet in depth, and still it flowed on. It entered a hoary forest, and the giant growth of centuries was cut down before it, like grass before the mower's scythe. No obstacle can arrest it in its

descent to the sea. Mounds are covered over, ravines are filled up, forests are destroyed, and the habitations of man are consumed like flax in the furnace. Truly, 'He toucheth the hills, and they smoke.' The eruption seems to have broken out through an old fissure, about one-third down on the side of Mauna Loa, on the north-west side, and not from the old crater on the summit, called Mocquoweoweo. The altitude of the present eruption is about 10,000 feet above the level of the sea."

Volcanoes appear, from observations made during the last hundred years, to be in sympathetic connexion with earthquakes; and probably the exciting cause of both phenomena is absolutely cognate. The regions subject to earthquakes include all the volcanoes which have not become extinct; and it has been remarked, as a curious and suggestive fact, that an earthquake is sure to be either attended or followed by the eruption of a neighbouring volcano. Indeed, there can be no doubt that earthquakes are owing, like volcanoes, to the agency of the

internal heat of the planet on its crust. Resting on a cavernous base, the crust is subjected, at certain periods, to the action of vapour, generated in those gloomy recesses from subjacent lavas, and the rocks above being elastic, acquire an undulatory motion, which produces disruption. An eminent authority attributes the movement to "an actual pulsation, engendered in the molten matter itself, by a linear disruption under enormous tension, giving vent to elastic vapours, which escape either to the surface, or into cavernous spaces beneath." The vibration is vertical, horizontal, or rotatory. The undulations, yielding to the impulsive force, most frequently expand in circles, and spread with a rapidity perfectly astounding. While the massive rocks heave in waves of commotion, the soil, possessed of no power of cohesion, runs about like water, shaping its course according to the inclination it receives. An explosive noise, more or less loud and protracted, usually precedes or accompanies disruption, but this is not invariably the case, and I have been present during a shock in

Malta without hearing any noise. Nor is the volume of the detonations in ratio with the violence of the shock.

The great earthquake of Tanguraga, the most devastating and extensive on record, was not attended by any noise, though detonations were heard about half an hour subsequent to the disruption, at a considerable distance from its centre. The noise usually has a hollow sound, resembling what would be created by the passage of a number of heavy waggons through a vault, with explosive claps like thunder; and occasionally, when the shock has been scarcely perceptible, the reports have had a ringing sound, such as is caused by the collision of metals. On the other hand this subterraneous thunder is sometimes heard, in districts subject to volcanic action, when the surface of the earth is undisturbed, and no convulsion follows. In 1784, the city of Guanaxuato, in Mexico, was visited by one of these subterraneous storms, which lasted, with brief intermissions, for nearly a month. During the earthquake at New Grenada, in 1835, similar detonations were

experienced in several of the West India islands, though the ground was not in the least shaken. Such sounds, however, must certainly indicate internal commotion, and always awaken in the reflective mind an irresistible feeling of awe and dread.

But noise is by no means the most frightful phenomenon attendant upon earthquakes. Streams of scalding water, impregnated with a deadly stench, burst from the gaping fissures by which the ground is rent, with flames of fire, and torrents of boiling mud, and shooting up to an immense height, fall in a deluge on every side. Huge lakes, which have been undisturbed for centuries, are drained of their waters, and new ones formed in spots previously arid. The sea is thrown up from its bed, and impelled on the land, often submerging houses, villages, and forests with a single wave. In the great earthquake of Tanguraga, already mentioned, the surrounding valleys were filled with water, which rose to a height of six hundred feet, and brought destruction alike on man and beast. On some occasions, the land, after undulating in

various directions, is elevated, and on others, depressed. In an earthquake on the coast of Chili, in 1835, witnessed by Captain Fitzroy, in command of H.M.S. 'Beagle,' the ground attained an elevation at different points of eight, nine, and ten feet. Sometimes the elevated mass, after remaining stationary for a short period, subsides to nearly its former level, and resumes the appearance it presented originally. In other cases the rise is permanent, and the aspect and configuration of the region are totally changed.

The range of a shock of earthquake is at times incredibly vast. It is said that the great earthquake of Lisbon, in 1775, was felt over an area four times the extent of Europe. The shock of the terrific earthquake of Tanguraga, which ingulphed the cities of Riohamba and Quero, dislocated the ground for more than one hundred and seventy leagues, and at a considerable distance from the centre of action every town was heaped with ruins. To come nearer to our own era, the shock of an earthquake in Chili, in 1822, spread in a second of time over

a surface of one thousand two hundred miles, producing the most fatal effects at remote and unconnected points. Nor is the terrestrial commotion confined to land, as the ocean, far from the seat of disturbance, is thrown up from its depths, and vessels have felt the vibration a hundred miles from land.

On the 9th of November, 1852, the west of England was visited by a shock of earthquake, felt simultaneously at Liverpool, Carnarvon, and Manchester, and a second or two later, at Dublin and Wicklow. The weather was sultry and foggy, with drizzling rain. The shock, which took place at 4.30 A.M., lasted two seconds. At 4.35 a smart shock was felt at Malaga, and caused the greatest consternation.

Altogether there are notices of two hundred and fifty-five slight shocks of earthquake in Great Britain, of which forty-five have occurred in England, and thirty in Wales. They have usually been accompanied by foggy and sultry weather, and by a remarkable fall in the barometer. The greatest ever known in

England occurred on November 14, 1328, and did considerable damage to buildings.

The most awful circumstance in connexion with earthquakes is the consequent destruction of human life. In the earthquake of Lisbon, which lasted only five minutes, thirty thousand people perished. An earthquake in Sicily, in 1693, destroyed one hundred thousand lives. It is computed that forty thousand persons were killed at the great earthquake in Calabria in 1783; and in the numerous disruptions in Chili, the great centre of terrestrial disturbance, probably not less than one hundred and fifty thousand people have perished in the course of two centuries.

The fissures caused by the waves of commotion become outlets for gaseous exhalations and thermal springs, mingled with clouds of steam. The predominant emanation, according to Humboldt, is carbonic acid gas; and he conceives that, in the early ages of the world, when its internal temperature was much higher, and the fractures in the surface more numerous, carbonic acid was emitted in very large quantities. To

this he attributes the luxuriant vegetation which then overspread our planet, and which, on decomposition, formed, from its excessive absorption of carbon, strata of coal, paving the earth with carboniferous rocks. Thus a store of precious mineral was laid up for the use of man, while the atmosphere, subjected to the incessant action of the vegetable kingdom, was relieved of its load of poison, and adapted to the requirements of animated beings. With such foreknowledge and such care did the Lord of all power and might prepare the earth for his creatures!

The columns of steam thrown up in terrestrial convulsions, perhaps from a depth of two miles, force their way through every obstacle, but are condensed by contact with cold springs, flowing over beds of clay, and issue from the fissures in jets of thermal water, of a temperature varying from tepid to boiling. These Plutonic fountains are strongly imbued with mineral and earthy particles, blended with noxious gases, of which carbonic acid is the most potent. They are derived, in the first

place, from streams of pure water, which circulate, like blood, in the heart of the earth; and their temperature is in proportion to the depth of their source. The deepest springs have the greatest degree of heat, and gush forth, as from a cauldron, in a bubbling torrent, full of mineral and gaseous ingredients, salts, bitumen, and iron. They are chiefly found in volcanic countries, but a few exist, in equal vigour, where the ground is no longer subjected to internal commotion, though some local dislocation of strata, the effect of a primeval earthquake, affords the turbid and foaming water an outlet from the interior of the earth.

Ebullitions of mud escape through channels of a similar character, forming what are commonly called mud volcanoes. The operations of these vents, however, are on a very limited scale, and are usually intermittent. Mr. C. W. Day, in his recent work on the West Indies, describes the mud volcanoes of the Antilles as mere plug-holes, which have run nearly dry. The Devil's Wood-yard in Trinidad, the principal crater, is in very feeble ebullition, and seems

to continually diminish in activity. Indeed, it is believed, from the peculiar character of the phenomena attending the emissions, that the passage connecting mud volcanoes with the abyss below, the original seat of action, gradually closes, and thus the issue heals at its source.

The translatury motion of earthquakes, sometimes occasioned by very slight shocks, exhibits itself in landslips, by which a portion of ground is carried over another portion, and there permanently settled. In the coal districts of England landslips are frequent, but here they are owing, not to any internal commotion, but to the subterraneous excavations of the miners, who, in working the coal veins, derange the overlying strata, and thus cause a shift on the surface. Landslips produced by earthquakes are of more moment, and on a scale of far greater magnitude. The force in action is such, that it has proved sufficient, in some cases, to remove mountains; and, in others, has filled up valleys, and changed the course of rivers. Fields and vineyards, freighted with a golden

harvest, and planted with stately and umbrageous trees, have been transported bodily for several hundred yards, and sustained no damage; and even houses have been carried a similar distance without injury.

Such are the wondrous forces in perpetual operation within the interior of the earth, acting periodically on its surface. We tread on a huge machine, which, as it ploughs its way through space, regulates its momentum by internal evolutions. The earth is like a living being. It moves, it throbs, it breathes! But it is animated, not by the mere property of life, but by infallible and everlasting laws: by the divine intelligence of the Creator. It tells us of his might, of his majesty, of his eternal presence; and the more closely we examine it, the more forcibly must we recal the impassioned words of the Psalmist: "O, Lord, how manifold are thy works! in wisdom hast thou made them all: the earth is full of thy riches."

VII.

LIGHT.

Philosophers are divided as to the exact nature of the property of light, which by Newton is considered to be an emission of material particles from luminous bodies, flying through space at the prodigious rate of 192,000 miles in a second of time. That such is its actual velocity, as ascertained by repeated observations, none can dispute; but, in other respects, the Newtonian elucidation is not generally adopted, preference being now given to the etherial or undulatory theory. By this system it is maintained, with great appearance of probability, that the endless regions of space are occupied by a fine, subtle essence, called ether, which,

restrained by no limits, washes the remotest shores of the universe with an invisible ocean. The etherial medium is of so refined a character, that the stellar bodies, revolving round their orbits, move through its elastic depths without encountering any resistance, though there can be no doubt that its particles are susceptible of very decided agitation. Hence arise waves, or undulatory motions, which, spreading with excessive velocity, in every possible direction, produce the effect of LIGHT.

This beautiful and divine emanation moves in straight lines, and is composed, in the first place, of certain distinct and divisible parts, called rays, which derive their colour from the number of undulations attending their propagation. On alighting upon any body, a portion is reflected, and another portion, varying in quantity with particular conditions, enters the body, and is either transmitted through it, or absorbed.

Bodies are of three kinds: self-luminous, non-luminous, and transparent. Self-luminous bodies, endued innately with the power of ema-

nation, are the sources of light. Such is the sun, and such are flames, sparks, &c. Non-luminous bodies reflect the light thrown upon them by luminaries, but possess no power of emanation in themselves. The moon, as we all know, is of this character, borrowing her soft, silvery light from the sun. On the other hand, transparent bodies, though really non-luminous, eagerly admit light, and transmit it with but little inexactness. Air, water, glass, &c., are transparent, though in different degrees.

The colour of light in direct emanation is white, but, in its elements, it embraces seven different tints—namely, red, orange, yellow, green, blue, indigo, and violet. The particular hue is regulated, as already mentioned, by the ratio of etherial vibration, blue requiring more numerous undulations than red, while a graduating number of waves produce the various intervening tints. White light, compounded of the whole, may be resolved by absorption and refraction into the seven component parts. Three colours—red, yellow, and blue—are

called primary: the remaining four result from the combination of these, and are designated secondary.

Variations of colour, analysed by the searching power of the prism, sink into each other by shades scarcely perceptible, red passing into orange, orange into yellow, yellow into green, green into blue, blue into indigo, and indigo into violet. Each variation has a corresponding index of refraction, and the whole seven colours, after separation by analysis, may be again compounded, when the light resumes its original character, and becomes perfectly white.

Light cannot pass through a body, be its nature what it may, without diminishing in quantity, and it is found that even the most transparent substances transmit the precious element with reduced force, absorbing a portion in its passage. This process of absorption, so universal in its operation, is one of the great mysteries of nature, baffling every attempt at investigation. It is conjectured, however, that the minute atoms of light are resisted by the matter of the transmitting medium, and thus

are dispersed through its particles, becoming blended with the mass. Even air possesses the power of absorption; and water, in some cases so transparent, becomes at a certain depth perfectly opaque.

While a portion of light transmitted through bodies is absorbed, or lost, another portion is diverted from its course, receiving an impulse in a different line; and this result, from its faculty of driving back, is called Refraction. The effect of refraction is strikingly manifested in the atmosphere, which possesses refractive power in a high degree. Light, in fact, as it nears the earth, is turned aside by particles of air, and made to continue its course in a curve. It is found that the upper strata of the atmosphere, which approach more nearly to the nature of ether, offer less resistance to the luminous rays, and hence it is that a greater number of stars are visible from lofty heights than can be seen from the level of the ground. The refractive power is consequently greatest at the earth's surface, where the atmosphere, pressed down by the overlying strata, attains its

greatest density, and it follows that any object seen through this medium, such as a fixed star or planet, never appears in its real place, unless it happen to lie in a directly vertical line.

The power of atmospheric refraction is greatly influenced by temperature, as the density of the air, both on the ground and in elevated situations, varies with the degree of heat and cold. Excessive heat or cold materially heighten the refractive power, producing optical appearances of a marvellous and startling character, which, as departures from ordinary laws, are designated Unusual Refraction. Phenomena of this kind are very common in the East, where the temperature of the atmosphere, owing to the intermixture of different currents of air, is subject to frequent local changes. The famous mirage of Egypt is an example of the magical effect produced by such agencies. A recent traveller, in an account of a voyage up the Nile, gives the following description of an Egyptian mirage: "When about ten miles from Alexandria, we came on a rare, and, to strangers, most novel spectacle, which opened to us a land of en-

chantment. It was the Egyptian mirage; and the illusion was so perfect, that for some time I could not be persuaded that what I saw with such distinctness was not real. The vast plain of sand, stretching beyond sight, assumed the appearance of a boundless lake, smooth and serene as glass; trees projecting into the Desert, became capes and headlands, washed by the tranquil waters, and the white towers of the Suez telegraph, far in the background, were transformed into a fleet of ships. The scene held us spell-bound, and it was with a feeling of disappointment that we saw it vanish."

The Fata Morgana of Messina is a still more curious spectacle. Here, as the sun diffuses his beams over the azure sky, a phantom city, adorned with magnificent palaces and stately temples, rises, like a vision, on the placid bosom of the sea, while around are spread luxuriant meads, where flocks and herds pasture at will. The optical illusion observed on sea-coasts, of cliffs and trees elevated on the surface of the water, the counterpart of the adjacent land, is well known, and often occurs even in

our own country. Ships have been seen at sea, complete to the hull, before even their topmasts have risen above the horizon, and the appearance of a ship inverted, while the vessel actually represented is out of sight, is, in some localities, a common occurrence. The legend of the Flying Dutchman, so universally believed by sailors, has had its origin in this species of refraction. That the illusive image of a ship has repeatedly been seen in the cruising ground of the errant Hollander, is a fact well attested, and which no person of scientific knowledge will venture to dispute. I must confess to having felt great disappointment, when approaching the Cape of Good Hope, that I never fell in with the phantom rover.

Optic illusions at times present themselves in very curious and mystic aspects, which probably is owing as much to some weakness or temporary derangement of the sight, as to external refraction. Awaking one night from a sound sleep, I was surprised, on looking up, to observe a woman standing by the bedside. The room was wrapped in darkness, so that I could not, at

first, distinguish even the white blinds of the windows; yet the whole figure of my strange visitant stood forth, distinct and prominent. What was more singular, as showing the inscrutable nature of refraction, I made out the colour of its drapery, which was a green and white plaid, falling in a long gown on the floor. Quickly perceiving that the figure, however feminine in outline, was above the stature of woman, I became sensible that it was an illusion, and sat up in the bed to regard it more steadily. I was then struck by the grace and exquisite dignity of its attitude, and the softness of its outline. The whole disposition of the figure was emblematic of the profoundest sorrow; and, as I continued to gaze, it became next to impossible, with such appearances before me, to believe that I was contemplating a mere phantasma. To place this beyond doubt, I touched the figure with my foot, when it instantly changed into mist, and dispersed.

The most familiar effect of refraction, in connexion with natural phenomena, is the rainbow, which, as every observer of nature is

aware, spans the sky with its variegated arch, when rain is falling opposite the sun. This beautiful fabric is an everlasting testimony to the means by which the Creator, while possessing supreme and unlimited power, works out his will, and serves, at the same time, to commemorate to latest ages his covenant of mercy with man. From the moment that the radiant bow first appeared in the heavens, a symbol of stability and peace, it has renewed to a thousand generations, the benignant promise that, "while the earth remaineth, seed-time and harvest shall never cease." As soon as the ministering rain begins to fall, the divine banner, inscribed with that significant and memorable writing, is unfurled in the sky, and becomes a beacon of confidence to all mankind.

The rainbow is sometimes composed of two bows, a primary and a secondary; and in the space between, the eye may occasionally observe intermediate bows. Usually, however, only one is seen, embracing in succession the seven different colours, namely—violet, indigo, blue, green, yellow, orange, and red; and of these

the innermost is violet, and the outermost red. This primary bow is produced by the action of light on drops of rain, which, as they are discharged by the aqueous clouds, in the region facing the sun, become a medium of refraction, and display the seven constituent hues of light with the accuracy of a prism. The secondary bow, which has its colours reversed, is thrown off by the first, and consequently is much fainter in colour, the refraction and reflection being double.

It is probably to refraction, operating in conjunction with terrestrial magnetism, that we owe the phenomenon of the Aurora Borealis, more commonly known as the Northern Lights. This beautiful object seldom makes its appearance in our clime; but in the winter of 1837, passing through London at a late hour of the night, I saw its streamers displayed in great perfection. It first appeared as a rack of red clouds, hanging immediately overhead: but in a few minutes, it spread, on lightning wings, over the whole city, draping the heavens with flame. The few stragglers in the streets con-

templated the magnificent spectacle with wonder and awe, and these motley groups of observers, summoned in the dead hour of night to behold the marvels of nature, presented a spectacle scarcely less startling. The phenomenon, however, was of short duration, and in half an hour the whole fabric had vanished.

It is in the ice-bound regions of the North that the Aurora Borealis is seen in all its grandeur. The author of "Revelations of Siberia," a lady of no ordinary observation, thus describes its appearance at Berezov, in Siberia, in the winter of 1840:

"At ten o'clock at night, a loud crackling noise was heard in the air, as though coming from a distance. The Berezovians were not slow in divining what this uproar in the atmosphere betokened, but almost before they could rush to their windows, the whole of the environs were enveloped in one blaze of illumination. Called by our landlord, we hurried into the court-yard to contemplate the phenomenon, and were enraptured at what we saw; but to

describe the spectacle is beyond the power of my feeble pen.

"The night was frosty and clear. Every object around the earth, the forest and the town, were white with snow. Berezov was no longer a miserable collection of huts, but radiant with lights, reflected by its covering of snow, looked like a world of enchantment. The different parts of the strange scenery seemed to form but a single grand and stately structure — a structure with walls of flame, surmounted by a cone-like cupola of fire, which towered over our heads. The light was neither red nor lurid, but beamed with mild, soft, indescribable lustre, unlike anything that can be imagined.

"The entire fabric, as it seemed, gradually threw off the cupola, and assumed the form of a sugar-loaf. It was narrow at its base, but the summit or apex of the cone rose to such an immense height, as to bewilder the vision. It appeared as though it even penetrated the vault of heaven, and at that hour of extraor-

dinary solemnity, permitted mortals, though but for a moment, to catch from their earthly vale a glimpse of that mysterious region inaccessible but to the spirits of the blessed.

"The walls of the wondrous cone were formed by light floating clouds of silvery brightness, which curling upward like volumes of thin smoke, spread their luminous rays in every direction. These clouds rose like vapours from the base, as if they were engendered in the earth, and rolled rapidly up to the summit, where, after covering the apex, they vanished as quickly as they had ascended. Their disappearance, however, did not in the slightest degree interrupt or diminish the splendour of the spectacle, and fresh volumes of cloud continued to roll up in all kinds of fantastic shapes, and with the same brilliant effects.

"These floating walls completely blocked out the sky, so that nothing could be seen of the blue vault of heaven or the countless stars. The eye could only behold the wonderful evolutions of masses of light set in motion by an invisible hand, while the ear was enchained by

majestic strains of harmony, with which the whole atmosphere resounded.

"The Aurora was undiminished in brilliancy for several hours, but afterwards its motions were less rapid, the coruscations of light faded gradually away, and at two o'clock all had vanished. The stars which up to that hour had been obscured or only partially visible, appeared in all their former glory; the moon shone brightly as it sailed over its clear azure path, and everything resumed its usual aspect.

"Wishing to ascertain what the Berezovians, who have not the slightest knowledge of natural philosophy, thought of the Aurora, I made inquiries with this view. The explanation I obtained from the wisest among them was, that the waves of the Arctic Ocean, reflecting the light of the moon, threw back a radiance on the sky, whence arose all the effects of the Aurora."

Light falling at certain angles, cannot, after acting on one transparent body, be a second time reflected or refracted, except in particular directions, nor does it retain the property of

penetration. The modified light is said to be polarized—a term suggested, in the first instance, by a misconception regarding the poles of the magnet, but which has since been universally adopted.

The phenomena produced by polarization are as numerous as they are beautiful, and while they charm the eye by their picturesque character, possess the higher merit of unfolding to us, in their marvellous effects, what Sir John Herschell happily calls "the minuter mechanism of the universe." Polarization may be accomplished, as numberless experiments attest, by reflecting substances of every description, but not at the same angle of incidence, or with equal completeness. Substances endued with a great degree of refractive power polarize with less facility, and only to a limited extent. The diamond, in which the property of refraction is very active, polarizes but feebly. Thus the queen of gems becomes valueless in the production of these dazzling and wondrous phenomena.

Polarization is continually affording us some

new insight into the secret operations of nature; and surely it is a significant circumstance, that one of our guides in that vast field of inquiry, which embraces so much that it concerns us to know, is LIGHT. We are turning this mighty power on a region hitherto enveloped in Egyptian darkness, and, at every step, our eyes discover, with mingled reverence and joy, fresh traces of the chain of design which encircles the universe. No longer can it be denied that we are surveying the works of an all-wise and all-powerful Being, which symbol forth, in characters appreciable by the humblest understanding, his majesty and his supremacy. As we pause in awe-struck wonder at results so sublime, it is meet that we should recal those dread and thrilling words, "I form light, and create darkness," and declare, with fervent and devoted faith, that to Him indeed "darkness and light are both alike."

VIII.

THE CELESTIAL FIRE.

The examination of the principle of light naturally directs our attention to that of heat, with which, if we may receive the conclusions of philosophers, it is identical. Nor is it in any degree less important, or less necessary. As light is the life of Nature, and air her breath, heat, which works invisibly within, may be considered her soul. It is, in fact, the celestial fire of Prometheus, which pervades, animates, and sustains all things.

Without heat, nothing could exist. Not only is it indispensable, as a quality of being, to every class of animal and organic life, but it

is found in every form and condition of matter. The creatures that walk the earth, the fish in the depths of the sea, the bird that, far beyond the reach of sight, cleaves with agile wing the crystal fields of heaven; land, water, and air, even hail and ice, are penetrated in various degrees by this subtle and vital property. Innate, commingled, and unsearchable, it leavens every substance, and is the leading agent in every development. Art and Science, and all the mechanical accessories of life, as well as the operations and whole economy of nature, depend altogether on the action of heat.

The universality of this power, and the benefits it confers upon mankind, both directly and through the medium of art, were recognized in the first ages of the world. Fire, as the presumed source of light and heat, was invested with divine functions, and adored as the symbol of the Creator. Man thought that he could not sufficiently revere a force which exercised such unlimited sway, and to which he owed so many blessings. It was heat that, by its fostering rays, covered the earth with trees and flowers,

and afterwards refreshed it with rain. To heat he was indebted for food, clothes, and every household comfort. Heat it was that imparted an invigorating warmth to his frame, and endued him, in its effects, with life, strength, and motion.

The distribution of heat is regulated by the Divine Hand with the most beautiful precision and forethought. The mind can conceive no scheme of measurement so accurate, no balancing of cause and effect so mathematically exact, as the adjustment, by relative position, of the quantity of heat which the earth receives from the sun. An eminent professor has announced, as a fact not to be disputed, that were the distance between our planet and the great luminary diminished, the access of solar heat would convert her waters into air, while the rich stores of metal garnered in her bosom would become brazen rivers, discharging themselves, when their course was run, into the vacant depths of the ocean. If the distance were increased, the difference, from the directly opposite effects, would be no less decided. The

diminution of solar heat would cause the air to liquify, turn the sea into crystal, and bind the great continents of the earth in eternal frost.

The nature of heat, like that of light, is a subject on which philosophers are not agreed. It is held by some, that heat is a material substance, residing in all bodies, and blending itself with their constituent particles. An accession of heat, therefore, when diffused through the parts, causes the body to expand, though the degree of expansion varies according to the nature of the body. The proportion in which bulk can be increased is governed by the affinity subsisting between the constituent molecules and the infused particles of heat—bodies in which the attraction is slight, being, with an infusion of equal quantity, susceptible of greater augmentation than bodies in which it is strong. But this theory is open to one objection, which would seem to render it untenable. It is well known, that all matter, whatever may be its particular character, is subject to the great law of gravitation, but this quality does not reside

in heat, and consequently, it cannot be considered a material substance.

Another theory, sanctioned by the venerable names of Bacon and Newton, derives heat from the same origin as light—namely, vibrations of the ethereal fluid, propagated through space with inconceivable velocity. This wavy motion is communicated to the particles of bodies, and causes them, without perceptibly separating, to move round their axes, or round each other, thus generating the power of heat.

The identity of heat and light, virtually asserted by this theory, is attested also by the similarity of their media—two main sources of heat being solar light and electricity. Percussion, compression, friction, and chemical combination, by which heat may be produced, are equally capable of kindling light. Indeed, the Indians of North America, unacquainted with the more ingenious contrivances of civilized life, obtain sparks for their fires by the friction of two pieces of stick, as if Nature had a spontaneous and instinctive perception of the characteristics of matter.

The quality of incandescence is another witness to the sameness of heat and light. A body is said to be incandescent when, by the absorption of a certain quantity of heat, it acquires the power of emitting light. The degree of heat, too, as of light, is indicated by colour. Iron raised in temperature to a red heat, becomes luminous, but in a less degree, both in quantity and power, than when the heat is heightened to orange; and orange, in its turn, yields to the superior effulgence of white heat.

Nor does the resemblance of heat to light end here. It is diffused, like the more subtle emanation, by means of rays, which have a divergence corresponding with the radiation of light. It has the same power of penetrating bodies, and, according to the nature of the mass, either passes through, or is partially or wholly absorbed. Absorption is attended by an increase of temperature, which, in some substances, rises to that of the body from which the heat is derived. The rays, too, like those of light, possess the qualities of reflection and refraction.

The application of heat causes some substances to ignite, and the light evolved then takes the form of flame. Combustion—for by that term the effect is designated—is a consequence of the exposure of heated matter to the air, by which it is brought in combination with the atmospheric gases, and the heat increased till it becomes luminous.

As all bodies are not capable of combustion, it follows, as a necessary result, that they will not be equally affected by the same proportion of heat. Each body, therefore, has a different temperature, which varies with its density; and the quantity of calorific fluid which it retains is called its specific heat.

The specific heat of a body regulates both its magnitude and temperature. The natural effect of any accession of calorific power, from whatever source, is to cause the particles of a substance to swell, and this necessarily increases the bulk of the whole. The augmentation of dimensions, which is proportioned to the elasticity of the matter, is called Dilatation.

This property of heat is in constant opera-

tion, changing the dimensions and temperature of bodies with every moment, although, in ordinary cases, unless tested by scientific instruments, the change is too minute to be perceptible. Should the temperature of a substance, however, be for any period the same, its magnitude remains stationary, and is only disturbed when there is any alteration of the temperature. When heat is abstracted, the body contracts; and when heat is infused, the result is an immediate and uniform enlargement.

The dilating faculty of heat is exhibited very strikingly in the atmosphere, where, by that divine economy of causes which forms so conspicuous a feature in the creation, and so glorious a testimony to the constructing hand of the Creator, it is made the agent of a very essential effect in the great scheme of nature. From the action of heat on the atmosphere, indeed, arise all the phenomena of winds, which are wholly governed by variations of temperature. When the atmospheric gases are invaded by heat, whether discharged from the sun, or sent up from the earth, their particles

dilate, and, in making room for increased bulk, push away the colder air, which of itself has a tendency to contract. A diminution of heat, spread rapidly through the region, is followed by contraction, and as the subsiding gases recede, the colder air presses up, forcing it, as the lighter material, to rise higher, when the whole of the adjacent strata are deranged. From this confusion spring the winds.

The change effected by heat in the dimensions of solids is on a smaller scale, and not so easily ascertained. Lead, one of the weightiest of solids, shows the greatest amount of dilatation, but the quantity is insignificant in comparison with the bulk. The expansive quality of iron is very minute, though on examining the rails on a railroad, in very sultry weather, I have been able to detect the enlargement. The difference, perhaps, would not have been perceptible under other circumstances, as the expansion is uniform, and spread equally through the length, breadth, and thickness. But the rails being laid in a line, and each pressed at its extremities by the rail adjoining, the

expansion in length cannot be accomplished, and, as a consequence, it is thrown up in a protuberance at the end of the rail, where the pressure is greatest. On the other hand, the abstraction of the calorific power, by an alteration in the temperature of the air, causes the rails to contract, so that an interstice is created between each rail.

Among liquids, water displays the most marked effects under peculiar variations of temperature. It is found that, after attaining a certain coolness, the contraction of this liquid ceases, and though heat may continue to be abstracted, the bulk of the water is undiminished, and remains stationary till the temperature is lowered to a point variously estimated, but ranging between 39° and 40°. With any further diminution of heat, water, contrary to all analogy, assumes an expansive quality, and goes on dilating, with every fresh fall of temperature, till it is frozen. The point at which it freezes, computed by the scale of Fahrenheit, is 32°. Frost, however, does not invariably accrue from this temperature, and water sometimes retains

its liquid form under a degree of cold much more severe. As soon as congelation takes place, the dilatation is very striking, causing, as an inevitable consequence, a considerable rise of level, which only terminates when the body is converted into a solid. At the same time, the calorific power, antagonistic though it is, is not wholly dismissed, a portion remaining latent in the ice. It is called latent, because it does not render the ice warmer, and heat imparted to ice in its transition to the liquid state, though possessing sufficient force to dissolve the constituent particles, is impotent in its effect on the temperature. Ice is endued, however, with a singular capacity for attracting heat from neighbouring bodies, and this accounts for the degree of cold usually attendant on thaws, during which, by the operation of this peculiar property, ice absorbs the heat of the atmosphere, and renders it latent till congelation disappears.

The boiling point of water is 212°. At this temperature, it begins to bubble, a natural result of its expansion, by which each par-

ticle, enlarged in an excessive degree, presses on every side against the particles around, and a general displacement ensues. This commotion is familiarly termed boiling, and is the stage at which water attains its greatest heat, when the calorific fluid, in whatever force it may be applied, can no longer raise the temperature. But should the heat be sustained, the water, still kept in ebullition, is converted into vapour, and becomes a new and more subtle element. Hence we derive the marvellous and prodigious power of STEAM.

Steam is analagous in its nature to air, but is invisible, for the vaporous smoke which ascends through a tube from boiling water, is, in fact, not steam, but minute atoms of water recovered from the ascending vapour by the action of the atmosphere. The steam, meanwhile, expands in a wonderful manner, insomuch that each particle is enlarged to nearly 2000 times its bulk in water, acquiring with this enlargement a corresponding degree of pressure, by which, in proportion as it expands, it forces its way through the

air. The property of pressure is exerted, with even increased violence and force, when the boiling fluid is contained in a vessel, bearing against the sides in such a manner as, if proportioned in quantity to the resisting power, must inevitably rend them asunder.

Such is the restless spirit we have invoked from the deep, to dwell, like the breath of life, in the iron frame of the steam-engine, to carry us with the speed of thought over continents and seas, and bring the ends of the world into constant and intimate communion. Steam, water, the simple element which has nourished and sustained the world from its first creation, is now to be the apostle of commerce, civilization, and religion. War, with all its train of ills—ignorance, barbarism, and superstition—the crimes and excesses of savage life, and the horrors of idolatry, must ultimately be scattered and dispelled by this divine and unwearying missionary. To the mighty steam-engine mountains can raise no barrier, and gales offer no impediment: it throws a bridge over oceans, and, outstripping the swiftest ships, ploughs its way in the very teeth of the wind.

But it is not at the boiling point only that liquid generates vapour. In that condition, it vaporises, so to speak, in all its particles, though with more rapidity in those which are most contiguous to the calorific force. But liquids emit vapour from the surface, where they have free communication with the air, at every degree of heat. Vaporization, as it is called, is in unremitted operation from the surface of all liquids, and the particles thus discharged are immediately borne away by the currents of air, leaving room for a fresh distillation.

Another form of this process is designated evaporization, and is the agent which, under the directing power of heat, draws up from the seas and rivers of the earth vast quantities of water, which are stored in the mystic hollows of the clouds, and descend from those aqueducts of heaven, when their heat is abstracted, as dew, rain, hail, and snow. These moisten and refresh the earth, carpet its soil with verdure and flowers, nourish the umbrageous woods, and support and invigorate the waving corn. Having fulfilled the functions of fructification, they penetrate still further into the ground, and re-appear, at a certain depth, as fountains and

springs, to be poured again into the ocean. So complete, and so provident, is the great scheme of phenomena which regulates the economy of the earth !

While the abstraction of heat causes water to condense, changing the liquid into a solid, the restoration of the calorific power, in whatever quantity it may be imparted, does not immediately produce a contrary effect. Hence it is argued, with every appearance of probability, that heat, instead of dissolving, combines with the congealed body, and becomes a part of its substance. It is only under the continued pressure of heat, maintained with unabated force, that the frozen particles liquify, and, as the water remains at the same temperature, it necessarily follows that the heat infused has become latent. Heat may be sensible, however, even in a congealed body; and water partially solidified has been raised in temperature by the immersion of a piece of ice.

By the application of heat, metals are reduced to liquids, and this property, conjoined with their malleability, renders them the most useful accessories of human industry. In their liquid

form some metals may be turned to almost any purpose, and moulded to any shape. Gold, silver, or copper, however, sustaining a contraction in the transition from the liquid to the solid condition, cannot be cast to the figure of a mould; and, consequently, all coin receives its impression from a stamp.

The last great purpose to which heat has been applied is in relation to its effect on air, and the caloric ship, invented by Captain Ericsson, a Swedish machinist, and constructed in the United States, is the first result of this beautiful principle. The engine consists of a large working cylinder, placed over a furnace, by which the air, the motive power, is heated, and above is a supply-cylinder, or air-pump, connected with a supplemental receptacle, called a regenerator. This affords the hot air already worked, a passage, through a graduated temperature, into the cold part of the vessel, when, having all its heat abstracted, it is again susceptible of dilatation, and brought to act anew on the cylinder. The vessel, as is well known, is about to make a trial trip across the Atlantic, and the extent of the caloric power will then be fully ascertained.

Heat may be measured, with an accuracy perfectly unerring, by two instruments, the thermometer and the hygrometer, the latter of which, however, is used only in connexion with a very elevated temperature. The liquid adopted as a gauge, includes between its freezing and boiling points—the two extremes—a considerable scope of action, in both directions, beyond the freezing and boiling points of nearly all other liquids, and possesses, moreover, an acute sensibility to heat. This liquid is mercury, or quicksilver, of which a small quantity, purified from all alloy, is infused into a spherical cavity, terminating a tube of glass, and, under the action of different degrees of heat, it expands or contracts, necessarily effecting a corresponding rise or fall in the tube above. The precise point of temperature is indicated by a scale at the side.

Thus the invisible property of heat has been conquered by man, and becomes at once his benefactor and his slave. Its universal presence, in every substance, and under all circumstances, renders its subjection to science one of the greatest achievements of the human mind, while it furnishes a key to mysteries that would

otherwise be impenetrable. In heat, we have wrested from nature the secret of her vitality. Whether it darts on lightning wings across the heavens, or embalms itself, like a sealed spring, in the ice-bound depths of the Frozen Ocean, heat, sensible or latent, is still the same imperishable, sustaining, animating principle, by which nature and the world exist. Who can say even that it is not the ethereal essence which we call *life*, and which, like itself, is invisible and unsearchable? As the spark of life begins to expire, our frames gradually lose their warmth, and grow colder and colder. Heat, enfeebled by the strain on its powers, or swayed by some undiscovered law, recedes from the extremities, but lingers for a while in the panting recesses of the heart. Then the breath of man "goeth forth out of his nostrils, and all his thoughts perish."

IX.

THE MYSTERIES OF THE DEEP.

THE ocean is the symbol of eternity. Boundless and unfathomable, it suggests to our limited understanding, at a loss for a parallel, the extreme of immensity. From pole to pole, from east to west, it is in perpetual and unremitted circulation—ever moving on, yet never passing for an instant its feeble and unguarded barriers. As we traverse this awful expanse, day upon day, and week after week, without seeing any bound to the rolling waters, but only the same everlasting flood blending on every side with the firmament, the mind receives such an impression of the majesty and sublimity of nature as nothing

else could inspire. In such a situation, amidst the silence and repose of night, while the canopy of Heaven is gleaming with myriads of stars, and no sound is heard but the whispering voice of the breeze, the most sluggish soul acquires a perception of the mysteries around. In higher natures, this manifests itself in a grave spirituality, which at once elevates and refines: in those of a more grovelling or timid stamp, it takes the odious form of superstition. At one moment, smooth as a lake of glass, but showing below a depth beyond calculation; at another, in fearful commotion, agitated by mountainous waves, and rent by tremendous chasms, the ocean is indeed ever suggestive of vicissitude, of adventure, and of danger. In this light, it has always been a favourite simile of the poets, when, in the sweet measures of song, they have dwelt on the mutations of human fortune, and the instability and frequent changes of life. In fact, it is a familiar custom, common to every age, and perhaps every nation, to associate the sea with all that is precarious, fickle, perilous, and unknown.

A subject so susceptible of metaphorical application could not be overlooked by the sacred writers; but we find in the Scriptures, on the whole, fewer allusions of this character than we might expect. When the fruitful theme is touched upon, the aim is chiefly to show that the mechanism and complete economy of the ocean, which seem so amazing and so inscrutable, are the immediate work of the Almighty, and hence to create a proper idea of His wisdom and power. Solomon refers to it frequently in this light, and always with the same devout purpose. "When He established the clouds above," he exclaims—"when He strengthened the fountains of the deep; when he gave to the sea His decree that the waters should not pass His commandment." David expresses a kindred sentiment, with equal eloquence and force.—"They that go down to the sea in ships, and have their business on the great waters, they see the works of the Lord, and His wonders in the deep." The royal lyrist's description of a storm at sea, so well known to the Scripture student, is one of the grandest passages in the

Psalms.—"For He commandeth and raiseth the stormy wind, which lifteth up the waves thereof. They mount up to heaven, they go down again to the depths; their soul is melted because of trouble. They reel to and fro, and stagger like a drunken man, and are at their wit's end. Then they cry unto the Lord in their trouble, and He bringeth them out of their distress. He maketh the storm a calm, so that the waves thereof are still. Then are they glad because they be quiet: so He bringeth them unto their desired haven."

It is conceived that when the earth was a fluid mass, its figure was an ellipsoid of revolution; and the ocean, undisturbed by the influences of the sun and moon, retains this form, marked by a compression at the poles. The mutation of the earth's axis would indicate that this world of waters is of almost infinite depth, but philosophers have come to a conclusion widely different. It is conjectured, though on purely hypothetical grounds, that the depth is uniform, so that no part of the main ocean is materially deeper than ano-

ther; and this depth, called the mean, is supposed to range between four and six miles. On October 30, 1852, Captain Denham, R.N., of H.M.S. 'Herald,' obtained soundings in the deep sea at 7,706 fathoms, or 7·7 geographical miles.

The surface of the ocean, as an inevitable consequence of its extent, is exposed to the action of the sun and moon, and the changeful influences of the atmosphere; but the combined effect of these agents is merely superficial. Even amidst the commotion and fury of a storm, when they are in full operation, the agitation of the waters is confined almost to the surface, and at a depth of some half dozen fathoms, it is perfectly calm. Stil these influences are abundantly sufficient to fulfil the functions assigned to them in the ministry of nature; and to the action of the sun and moon on the ocean we owe the phenomenon of the tides. The moon attracts the waters of the hemisphere beneath her, which is immediately subject to her sway, more powerfully than the solid bulk of the earth, drawing them away from the earth in such

a manner that, in a short period, the great deep would be altogether emptied, if the overruling law of gravitation, throned in the centre of the globe, did not lessen the attraction. At the same time the queenly satellite attracts the mass of the earth nearest to her in greater proportion than the waters of the opposite hemisphere, which, as a consequence, would be left behind, if the gravitating principle, by drawing them to the centre of the world, did not correct this tendency. The action of the sun is precisely similar, though, owing to a diminution of force, it is not so signal. Each agent, as in every function and ministration of nature, corrects and modifies the other, and the final result is, the alternate rise and fall of the waters, in both hemispheres, twice in the lunar day.

The fluctuations in the level of the waters, though in most regions of regular occurrence, are by no means uniform in quantity: the different changes and phases of the moon causing great variations in this respect. The spring tides, which reach the greatest altitude, and show the most marked decline, occur at

new and full moon, but they attain their highest elevation when the moon is in perigee. The neap tides, which are much lower, attend on her quadrature.

The variations in the level and time of high water are caused by the declinations of the moon, which altogether occupy $29\frac{1}{2}$ days ; but, though producing periodic derangements, these declinations are, in the aggregate, balanced by those of the sun, which, with a more limited range, require for their completion $365\frac{1}{4}$ days.

Though the tides are most decided in narrow channels, where the water is confined, the sun and moon act with the greatest force on the main ocean, where, in fact, the tidal waves originate. Even in a large expanse of water, the ebb and flow are slight, if the inlet from the ocean, as in the case of the Gut of Gibraltar, is so narrow as to check and repress the tidal rush. During a stay of nearly twelve months in the Mediterranean, I noticed but little variation in the general level of the water.

Whether the tides were at any period more powerful in the Mediterranean, is a matter that

cannot now be ascertained; but it seems probable, from modern explorations, that this noble inland sea formerly held less restricted communication with the Atlantic. The marine deposits near the Pillars of Hercules, left by vanished waters, seem to point at such a conclusion, but philosophers are not absolutely agreed as to the fact.

It is certain, from what passes year by year under our own observation, that the configuration of land and sea is continually varying, and I have endeavoured in a former chapter to explain how and by what means these changes are effected. I shall only remark here, that the sea, though in appearance stationary, gains on the land in some places, and recedes from it in others. This is apparent even on our own coasts, where, within memory, the sea has, at different places, both advanced and retired, in some cases quite altering the shape of the land. At Sandwich, on the coast of Kent, the inroad had been very decided, and at Reculvers the sea is only kept back by strong barriers, which break the shock of the invading waves.

The sea, swayed both by the sun and moon, necessarily exercises considerable influence on climate. Since the elevation of land in the north of Europe, the climate, which originally was tropical, as the deposits most amply attest, has been seized by eternal frost. On the other hand, in the southern hemisphere, where the ocean greatly predominates, the climate, in a latitude corresponding with the south of Europe, is at once salubrious, bracing, and temperate.

The rise and fall of the sea is exhibited in another phenomenon, familiarly called waves. Waves give the sea the appearance of a progressive motion, which never comes to a stand. But this progress, though seemingly most distinct, is an illusion, having no material or real existence. The motion is not in the water, but in the wave, which, while it appears to advance, merely alters the position of its parts. Thus, the base of the wave, seized by the rising water, becomes its slope, and the slope is converted into its pinnacle, while the sea itself rises and falls, but remains for ever stationary.

The power of a body to float on water admits

of easy explanation. In order to possess this property, the weight of the body must be the same, bulk for bulk, as water, or it must be of such a figure that, by only partially sinking, will displace an amount of water as much exceeding it in bulk as it exceeds the displaced water in weight. Bodies of this description must be ballasted, if I may use such a term, by air. A certain space below the water line, varying with the character of the body, being thus occupied, the lightness of the air reduces the weight of the bulk, and the whole is enabled to float. On this principle we construct boats and ships. But, in order to secure buoyancy to a ship, it is necessary, in the first place, to fix its centre of gravity, which, as a counterpoise to the weight of the spars and rigging, ought to rest on the keel. Hence it is that the heaviest part of a vessel's freight is stowed first in the hold, by which the main weight, instead of being distributed over the space, is thrown on the bottom, and a proper resistance offered to the action of the water. When a ship is void of cargo, or laden

only with light materials, the centre of gravity is maintained by ballast, composed usually of bars and pigs of iron, which lie beneath the actual freight, and secure equilibrium. If, by any casualty, the centre of gravity is disturbed, equilibrium is destroyed, and the vessel is ingulphed by the conquering waves.

The human body, with a little assistance from the hands, may invest itself with buoyancy, as it assimilates very closely in weight to its own bulk of water. Respiration, indeed, alters its bulk, the emission of breath collapsing, as its inspiration expands the frame; but the air received into the lungs makes no addition to the weight, and, consequently, the body, rendered lighter than its own bulk of water, has a tendency to rise. As the breath is emitted, however, the weight of the body is increased, and its size diminished, when a tendency of a directly opposite character is created, and the body begins to sink. I have frequently experienced, when swimming, the effect of unguarded respiration, causing me to sink with great velocity, and have only re-

covered buoyancy by prolonged and measured efforts.

Few are ignorant that, after drowning, a corpse will rise to the surface and float. It has in fact, by the process of decomposition, increased in volume; and becoming lighter, bulk for bulk, than water, is endowed with buoyancy; but evaporization, consequent on exposure to the atmosphere, again reduces its bulk, and it then sinks for ever.

The principal of relative weight is beautifully illustrated in the structure of fish, which, to adapt them to their sphere of existence, are furnished with an elastic air-vessel, equally susceptible of expansion or contraction. Thus the animal is able, by inspiration, to augment or diminish its magnitude, and rise or sink at pleasure.

From these examples, it will be understood, without further explanation, that a body which disperses on immersion a less amount of water than is equivalent to its own weight, will infallibly sink; while, on the other hand, a body equal in weight to its own bulk of water, will

float. But, whatever may be the weight of a body, it is more easily moved under water, where the aqueous pressure assists progression, than on land, insomuch that a man will move a weight in the water unaided, which on land half-a-dozen men would move with difficulty. The pressure thus exercised by water is a common property of all fluids. Whatever position a fluid may occupy, or whatever may be its volume, it communicates a pressure to every point, each particle being pressed in proportion to the weight of the quantity of fluid above it, and the quantity on each of its four sides. It is this pressure, in fact, which keeps the particles of the fluid together, and therefore it follows, as a necessary and natural result, that the pressure must be uniform. Nor is it possible to conceive any means by which it can be interrupted, as it is exerted, at one and the same time, both in an upward and downward direction and on every side. Each particle presses the one adjacent, which, by its resistance, exercises a similar force, and thus the whole unite in one indissoluble mass.

If water or any other fluid be confined in a vessel, the pressure will be directed against the sides and bottom of the vessel; and its amount will depend, not on the quantity of the fluid, but on its depth, and, in great measure, even on the depth of the vessel. Thus, if a tall vessel be only partially, and a shallow one completely filled with water, the pressure in the tall vessel will be greater, from the concentration of force, than in the shallow one, although the latter contains the greatest quantity of water. In like manner, the width of the vessel, by which the quantity of the contents must be regulated, in no way affects the pressure; and a narrow vessel filled with water is subject to the same amount of pressure as a wide one. A vessel sustains the greatest strain in its deepest part, and the nearer a point is to the surface, the less it is exposed to pressure.

This strange property of water, the test and characteristic of a fluid state, is linked with another, no less notable; namely, equality of level. The component particles of all bodies,

whether liquids or solids, have a tendency to fall to the bottom; but in solids, the cohesive power of the particles prevents this result. As a consequence, the earth, instead of having one uniform surface, is beautifully and endlessly diversified: its mountains rise to the clouds, and smiling and fruitful valleys, clothed with nature's fairest products, are spread over her bosom in every direction. But liquids, insensible to the principle of cohesion, are wholly governed by gravitation, and each particle falls invariably to the lowest depth. For this reason two reservoirs of water communicating with each other, by however small a channel, and at whatever distance, must necessarily be continually of the same level. To this cause also, we owe the various phenomena of springs, brooks, and cataracts. The mechanism of springs and brooks, as the main sources of rivers, I have already explained; but that of cataracts belongs more strictly to our present subject. A number of brooks having collected into one stream, at a considerable height above the level of the sea, the water is impelled by the prin-

ciple of gravitation to precipitate itself into the lowest position, and thus rushes over any declivity that may lie in its way. Hence arise the grand and romantic phenomena of cascades and cataracts, which form one of the most sublime features of nature, and show at one view, and in the most striking aspect, all the varied characteristics of water.

X.

THE ATMOSPHERE.

THE wonders of nature are so familiar to us, are spread around in such endless profusion, and so inextricably blended with our existence, that we scarcely appreciate their marvellous and intricate mechanism. We are but too apt to regard them as matters of course, without pausing to investigate their manifold functions, or to consider, with the philosopher and man of science, how they minister to our requirements. We may indeed admire their beautiful unity, but for the most part, we are but imperfectly acquainted with their design, mode of operation, tendency, and effect.

Among these household phenomena is the atmosphere, which, extending alike over land and sea, envelopes the world with a life-giving fluid, the most precious gift of heaven. Air, the common appellation of this subtle essence, penetrates every interstice, and animates and sustains all things. It is the primary essential of vitality, and by it we live, and move, and have our being. The economy of means which forms so grand a characteristic of the Creation, in its minutest as well as greatest operations, is here most strikingly exhibited. The seed in the ground, the verdure on the surface of the earth, the golden corn, the tree and its fruit, the living creature and its food, with scarcely any one affinity in common, owe their existence and development to the same benignant agent, and thus the first provision of life displays, in its universal application, the constructing hand of an Omniscient Architect.

Air is a visible, material, elastic fluid, blue in colour, and capable of almost illimitable expansion. It is composed of minute globular particles, which are in ceaseless motion, revolving

round their axes, and, though these evolutions are not usually discernible, under certain conditions of temperature the particles solidify, and their movements are then apparent. The author of "Revelations of Siberia," to whose valuable observations I have before had occasion to refer, thus describes this rare phenomenon, as witnessed by her at Berezov.—

"The air was clear, but was in incessant motion, I might say, tremulous agitation, almost visible to the eye; as though it were composed of a solid mass of tremulous atoms, ever revolving, moving, and vibrating."

The editor of the English translation of the work adds, in a note, the following interesting facts—

"This peculiarity of the air is not limited to Siberia, but may occasionally be observed in portions of northern Europe. The editor happened to witness a remarkable instance of it in his early youth, on the southern boundary of Prussia, near Oletzko, on a clear hot day in August, when the atmosphere seemed not only to consist of moving atoms, as described by

our authoress, but was like a hard compact mass, tremulously shaken, and even resounded audibly."

I believe this is the first authenticated record of the solidification of air, although the Masters of Science, arguing from analogy, have long concluded that the atmosphere possessed the properties common to more definite bodies, and was capable both of solidification and liquefaction. As they have proved correct in the one inference, it is not unreasonable to suppose, when the field of observation is continually being enlarged, that they will one day be corroborated in the other, and that air will be seen in a liquid form, as well as in a solid.

Air is peculiarly subject to the repulsive principle, by which its particles, instead of coalescing, act on each other with a repelling power, and are thus in constant antagonism. The effect of this conflict is to invest air with the property of expansion, which it possesses in a very remarkable degree; but as unrestained expansion, by raising it from the earth, and allowing it to dilate in space, would be productive

of the worst results, the atmosphere is endowed also with the quality of compressibility, and, by such means, the aërial masses above weigh down the underlying strata, while they are themselves enchained, after dilating to a certain point, by the mighty law of gravitation. To such minute arrangements does God extend the ministry of His overruling providence!

It is a principle of nature, admitting of no exception, that the subdivision of matter cannot pass beyond a particular limit. Air is elastic in proportion to the amount of force by which it is restrained, and, in this position, is invested, in a corresponding ratio, with the same faculty of pressure which has been observed to reside in liquids. But as the restraining force is diminished, the quality of elasticity, meeting no resistance, becomes less active, and, after again and again dividing, air becomes stationary in its constituent particles. It is then that, reduced in weight and force, the particles lose their repulsive tendency, and become subject to gravitation. Still, the atmosphere, as a necessary effect of its elasticity, is diluted in proportion to

its height, and its ultimate condition is one of extreme attenuation and rarity.

The total height of the atmosphere has been estimated at about fifty miles, but probably it is not of sufficient density to sustain life by free respiration at a greater elevation than five miles. I have ascended a lofty mountain in Africa without observing any material difference in the density of the air; but such expeditions, whether from local circumstances, or from the idiosyncrasy of the individual, are not always attended with the same result. Humboldt complains that, in ascending the Andes, blood burst from his lips and ears; and Gay-Lussac experienced great difficulty in breathing at a height of four miles, to which he ascended in a balloon.

On the 10th of November, 1852, Mr. Welsh, of the Kew Observatory, ascended in the Nassau balloon to a height of 20,400 feet, or nearly four miles. The temperature at the greatest elevation was 11° below zero, 43° below freezing point. The dryness of the air was excessive, and respiration painful and difficult. A French aeronaut, who made a trip in a balloon

on horseback, in the summer of 1851, observed that blood poured from the horse's nose and mouth, as in the case of the great German philosopher, at an elevation of a few thousand feet, though he himself appears to have breathed with perfect freedom at a much greater altitude.

It is the extreme height of the atmosphere that enables us to ascertain its colour, the masses which overlie each other, in successive strata, presenting the appearance which we call "sky," in the same way that all objects at a distance seem *blue*, the intervening extent of air, which is the medium of view, colouring them with its own tint.

I have already spoken of air in its solid state, and we now see that, like all bodies, it possesses colour; and, in fact, is visible. But it is endowed with two other qualities of materiality—namely, weight and resistance.

Air has been actually poised in the balance, and its weight ascertained with the greatest nicety. It is found that, at the level of the earth, the amount of pressure which it exerts on a body in every direction, is at the rate of

15 lbs. to the square inch; so that a full-grown man, whose body presents a surface of 2000 square inches, is positively loaded for life with a burden of 30,000 lbs. It might be supposed that so ponderous a mass would make some perceptible impression on the frame, or even be sufficient to crush it; but far from exercising such an effect, it is absolutely necessary, as an external agent, to preserve the completeness of our organization. The pressure which the air directs on the surface of the body, is proportioned to the pressure which the blood and gaseous fluids, circulating in the various organs, exert on the interior, and thus one force totally counteracts the other. But for this beautiful provision of the Deity, the blood would gush from our lips—as we have seen in the case of Humboldt, when the amount of the atmospheric pressure was lessened—and every living creature would perish.

Resistance, a most decisive proof of materiality, is that force which a quiescent body opposes to a body in motion, when by any contingency they come in collision. This

quality depends on impenetrability, by which the body at rest, however powerfully it may be struck, is able to repel the advance of the assailing body, until, by displacing some third substance, it has lodged itself in another position. In riding or walking quickly, we may notice that we do not open or penetrate the air, but that it flies before us, and, in fact, resists our progress till it has itself displaced the masses beyond. The moving body thus loses an amount of force, equivalent to that which the body subjected to the shock acquires.

The most general cause of atmospheric disturbance is heat. It is to fluctuations of temperature, which contract or expand the air, and consequently derange its equilibrium, that we owe all the phenomena of winds. Of these the most important are the Trade Winds, which, by their prevalence in those latitudes where we might expect to find a perpetual calm, throw a bridge over the pathless ocean, and enable the ends of the world to communicate. The Trade Winds are caused by the action of the sun on the atmosphere at the equator, operating in

conjunction with the rotation of the earth on its axis. The upper strata of air, under the rarefying influence of the solar rays, are driven towards the poles, while the subordinate and cooler strata fly along in the opposite direction from the poles towards the equator; but their rotatory motion being corrected by the velocity of the earth, their northerly and southerly inclination is subdued, and they receive an easterly impulse, blowing from the north-east in one hemisphere and from the south-east in the other.

The Monsoons are another class of winds, confined to the Indian and Eastern seas. They are caused by a diminution in the amount of solar action, which, agitating the atmospheric currents, produces periodically winds from the north and south, directed towards the east by the rotatory motion of the globe.

Hurricanes are thought to be owing to the intermixture of different currents of wind, in the masses immediately over the surface. The rotatory impulse, which is first acquired in the upper strata of the atmosphere, carries the

storm round a progressive axis of rotation, inclined forward by the friction of the earth; and, in consequence of the varied temperature of the commingled currents, is attended by frightful precipitations of rain, with thunder and lightning. The storm sweeps along with terrific velocity, sometimes covering a thousand miles in a day, and in its progress tearing up trees and buildings, and laying whole towns in ruins. Suddenly the awful tempest, by which all nature seems convulsed, ceases, and is followed by a dead calm, as the centre of the whirlwind, which remains in repose, uninfluenced by the circling blasts, steals on its treacherous way. Then the winds again bound on, blowing in every direction from the centre; and the dread conflict of the elements, instead of abating, acquires new violence and fury.

Whirlwinds descending on the sea, after proceeding some distance in the upper strata of the atmosphere, impart to the water a centrifugal force, by which it is raised in a spiral mass, forming what is called a water-spout. The velocity of the water-spout, when progressive,

is regulated by that of the whirlwind, and is frequently very great. Two prodigious water-spouts, which, in December, 1851, swept over the island of Sicily, together with a terrific hurricane, are thus described in the newspapers of the day:

"The water-spouts were two immense spherical bodies of water reaching from the clouds, their cones nearly touching the earth, and, as far as could be judged, they were a quarter of a mile apart, travelling with immense velocity. They passed over the island near Marsala. In their progress houses were unroofed, trees uprooted, men and women, horses, cattle, and sheep raised up, drawn into their vortex, and borne on to destruction. During their passage, rain descended in cataracts, accompanied with hailstones of enormous size and masses of ice. Going over Castellamare, near Stabia, they destroyed half the town, and washed two hundred of the inhabitants into the sea, who all perished. Upwards of five hundred persons have been destroyed by this terrible visitation, and an immense amount of property, the country being

laid waste for miles. The shipping in the harbour suffered severely, many vessels being destroyed, and their crews drowned."

Air is the medium through which we receive all the impressions of sound. If the world were not enveloped by this elastic fluid, it would be the seat of eternal silence. The thousand melodious notes which gladden and enliven nature, throwing an atmosphere of life over every object, would have no existence, and the human voice would be useless. The ear would no longer be susceptible of the concord of sweet sounds, and the terrific thunder peal, equally with the low hum of the meanest insect, would be unheard and unknown.

Sound is the effect of vibrations of air propagated by waves to every point. Its volume is in proportion to the force of the initial shock, and is susceptible of almost infinite variation. The human ear, by the delicacy and intricacy of its structure, is admirably adapted for distinguishing these differences of sound, and it is even supposed to be confined to no particular range, though in most cases,

according to the experiments of Wollaston, it is restricted to nine octaves. The hearing is most acute at night, when, owing to the augmented elasticity of the air, sound is propagated with increased velocity, and can be heard from the greatest distance. Sir John Herschell, while stating this fact, finds another reason for such a result in the solemn stillness which then universally prevails.

Sound is always propagated outwards, in straight lines; but recoils, like a ball, when driven against an obstacle, which, by its dimensions, is sufficient to intercept the undulation. It will pass with great velocity through glass and timber, and massive buildings, but is beaten back by mountains and caverns; and this *reflection* of sound, as it has been called, produces the beautiful effect of echoes.

Every sound is propagated at an equal rate of velocity, and hence we hear the notes of all the instruments of a musical band, however varied their volume, at the same instant. The extent to which sounds may be transmitted depends on the temperature and elasticity of

the atmosphere. Frequently they are audible at a great distance; and the famous Samuel Pepys, in his Diary, mentions having heard the cannonade between the Dutch and English fleets, in an action off the coast, more than thirty miles from the spot. The explosions at the memorable volcanic eruption at Sunbawa, were audible at a distance of many miles; and the report which accompanied the bursting of the meteor of 1785, resounded on the earth, a depth of fifty miles, like a clap of thunder.

Water, as a fluid susceptible of compression, possesses the quality of transmitting sound, though only in cases where the undulation is created below the surface, when its particles are subjected to the shock. It also propagates sound with greater velocity than air. Music on the water, in the calm stillness of a summer evening, has a peculiar charm :—

"Like music on the waters,
Is thy sweet voice to me:
When as if its sound were causing
The charmed ocean's pausing,
The waves lie still and gleaming,
And the lull'd winds seem dreaming."

XI.

THE WORLD OF PLANTS.

We have hitherto contemplated Nature in its magnitude and general outlines, or in reference to those more striking phenomena which pervade and conduct its operations. In all these aspects she presents the same marvellous unity, the same adaptation of means and end, the same significant and unerring design. We recognize in every law, and in every effect, the hand of an almighty and beneficent Creator, manifesting in his prodigious works infinity of wisdom and power. Worlds and suns and systems, spread in countless myriads over the regions of space,

give a faint idea of the unlimited extent of the Creation. The lurid volcano, which affords a passage of escape to the internal fires of the earth, like a mighty safety valve; the awful earthquake which destroys to reconstruct; and the implacable hurricane, show, in a grand and sublime manner, the wonderful character of its economy. The lightning that clears the atmosphere; the gentle rain, which moistens and refreshes the soil; the genial heat and glowing sunshine, which bring life and healing on their wings, are ministering witnesses to its tenderness and bounty. All alike proclaim, with solemn and impressive emphasis, the existence, omnipresence, and overruling providence of God.

But it is not so much in the more stupendous works of the Creation that God reveals himself to the bewildered eye and mind of man. Had it been so, thousands of years must have elapsed, ere the benighted world, aroused by the voice of Science, could have acquired any consciousness of his presence. But his unchanging attributes are equally distributed over the whole

universe, and not more signally displayed in the heavens, or in the intricate phenomena of nature, than in objects of the most familiar interest. In communing with man, indeed, the Creator has most frequently assumed a guise that, while fully consistent with supreme majesty, appealed not to his wonder, but to his devotion. Elijah looked for Him in the earthquake, the whirlwind, and the fire; but there was no convulsion or derangement of nature, when the small still voice, more imposing than thunder, swept softly over the holy mountain, announcing that God was there. And we learn from the wisest of Teachers, that even the meanest of his works, which we have come to regard with indifference or contempt, surpass in excellence and beauty the greatest achievements of human art. To say that Solomon in all his glory was not arrayed so sumptuously as the lily of the field, might seem preposterous to ignorant men; but the magic microscope, unveiling the secrets of the invisible world, shows how true is the assertion. Viewed through this medium, the finest and

most costly fabric of the loom, which has tasked the utmost reach of human skill, becomes hideous ropes and rags, while the beauty, grace, and exquisite finish of the lily is infinitely magnified. And if we descend still lower in the scale of the creation, we find perfection exhibited, with equal clearness, in objects too minute for sight. That great leviathan who takes his pastime in the deep, breasting its stormiest billows with his huge and unwieldy frame, is not more admirably or perfectly formed than the animalcule whose ocean is a drop of water, and which is only visible through the searching eye of the microscope. The Almighty, in fact, has set his seal on all his works, and the impression and effect are ever the same.

This vast field of observation we are now about to enter, that we may see the Creator reflected and preserved in the creature. Before, however, we proceed to survey the animal world, it is desirable that we should take a glance at that which, though equally pervaded by the principle of life, is vulgarly termed

inanimate, and which affords sustenance and aliment to the other.

It is impossible to look round on the face of nature without perceiving at once how much she owes to vegetation. Nearly 80,000 distinct species of plants, extending into untold varieties, lend their countless charms to diversify her features. The rugged mountain crag and the dismal savannah, hill and dale and plain and swamp; the yawning chasm and the frightful precipice, hide their nakedness with these beautiful products. Verdure of every shade, flowers of every tint, plants and fern, bush and shrubs and trees, as varied in appearance as in character, everywhere present themselves, gratifying the eye with the most pleasing combinations of form and grace and colour. From these we derive our first sense of the beautiful, and an inexhaustible store of delightful impressions. At the same time, they supply us with the most essential articles of sustenance; and, in their various delicious fruits, minister not only to our wants, but to our luxuries.

I have already remarked, that this boundless

kingdom of vegetation, which covers and adorns the earth, is infused with the principle of life; and so closely does the vital property of plants approximate to that of animals, that naturalists, after the most elaborate investigations, have been unable to fix the degree in which it differs. Plants not only live — they breathe. They perform nearly all the functions, and, though of an inferior and less intricate organization, have many of the characteristics of animals. Perspiration exudes from their pores; blood circulates in their intercellular passages; and their pliant frames, so curiously and elaborately constructed, are encased in skin. They eat and drink, and in some cases, strangely deviating from the general law, even require the stimulus of animal food. In the nepenthes, or pitcher-plant, one of the most singular and striking of these carnivorous flora, a tendril supports a hollow, deep vessel, shaped like a pitcher, with a membranous lid, which, after the plant has attained a certain development, is always raised; and in the bottom of the pitcher a glandular section is incessantly secreting liquid, which

serves as a trap for insects, and thus secures the required nutriment. The Venus's Flytrap has its leaves terminated by two lobes, margined with bristles, while three dwarfed bristles, grouped in a triangle, rise from the ridge of each lobe, so that an insect crawling over the leaf is sure to encounter a bristle, when, by a beautiful provision of nature, the shock is communicated to the whole fabric, and the leaf immediately folds together, remaining closed till the insect is absorbed.

But plants resemble animals in points still more significant. They have sexual distinctions; and propagate their species, so infinitely varied in character, in a manner not dissimilar to the parturition of human beings. To commemorate this resemblance, one of the botanical orders of Linnæus, the great Swedish naturalist, bears for its name a Greek word signifying "woman;" another is distinguished by a compound appellation, signifying both "woman" and "man;" and a third is designated "marriage." Of the organs and mode of propagation I shall speak hereafter.

The sleep of plants, exhibited in the leguminose family, presents a curious analogy to the economy of animal life. As day draws to a close, the leaflets of these voluptuaries assume a depressed appearance, strangely expressive of weariness; and by degrees, as the last traces of light disappear, they bend and fold together, and continue closed through the night. Morning brings them recruited vigour, expanding their leaves and flowers to the fullest extent. It has been found, however, that the leguminosæ placed in a room from which daylight was rigidly excluded, and where they were subjected to artificial light at night, have, after a short period of indecision, been brought to conform to this altered condition, and have closed their leaves during the darkened day, and expanded them at night. This reminds us of the custom which prevails among the inhabitants of Siberia, who, during the Arctic summer, when the parched and sultry night is as radiant as day, create an artificial darkness by obscuring the windows of their dwellings, and thus secure

more easily the blessing of sleep. So similar are the affinities of plants and animals !

Plants are subject to diseases, and to marked idiosyncracies, which baffle every attempt at elucidation. Two plants of the same species, derived from the same stock, and in every respect alike, may be placed in situations precisely similar, when one will flourish in a remarkable manner, and the other wither and die. Different species, and even varieties of the same species, removed only by some trifling characteristics, require a temperature wholly distinct, and the most opposite conditions of soil and culture. Their diseases are numerous, and have been reduced to a separate science, which bears the expressive but not euphonious appellation of Nosology.

The idiosyncracies of plants explain, in some measure, the wonderful diversity in their periods of existence. While some plants spring up but to die, and others live only till they arrive at maturity, certain tribes of trees, placed in situations favourable to their development, attain

incredible longevity. In the class of Dicotyledons, or Exogenæ, naturalists ascertain a tree's age with great precision, as the diameter of the tree is enlarged annually by a new cylinder of wood, and thus preserves an accurate registry of its own age. It is no uncommon thing for trees to brave the storms and vicissitudes of centuries. My lamented friend, Eliot Warburton, in one of the most picturesque chapters of "The Crescent and the Cross," mentions a group of cedars of great antiquity in the forest of Lebanon; and other travellers in the East speak of trees varying in age from 800 to 1000 years. Evelyn mentions a yew in a country churchyard which was sixty feet in circumference, and, judging from the lines in its diameter, must have been upwards of 2800 years old. De Candolle, who paid great attention to this branch of botany, furnishes a most valuable record of the results of his examination of a large number of old trees, including many different species, and extending over a variety of periods. Of these the most remarkable are an orange tree 600 years old, a lime 1100

years, an oak 1500 years, a yew 2500 years, a baobab 5000 years, and a taxodium (*Cypressus disticha*) 6000 years old, or, according to the alleged chronology of Moses, the age of the earth. Speaking of the Taxodium, De Candolle justly observes that it "certainly goes back to the origin of the present state of the world, an epoch of which it is the most indisputable monument."

But though this relic of the Creation would seem to claim immortality, plants share the fate to which all things mundane are condemned. The oak, with its sturdy trunk—the cedar, with its frame of iron, though surviving through countless ages, must at last yield to death. The king of terrors, never forgetful of his mission, reigns everywhere supreme; and plants and animals alike acknowledge his sovereignty.

Philosophers have in vain endeavoured to ascertain, by experiments and researches of every kind, what is that mysterious principle of life which so universally prevails, and after a term of uncertain duration, is thus infallibly and unreservedly extinguished. So impenetra-

ble and occult is the question, that it has hitherto, as I have before remarked, been found impossible to trace out even the distinctions and modifications of life, so as to fix the line of demarcation that divides the animal from the vegetable world. Divisions have indeed been made, but they are at once arbitrary and unwarrantable. The limit of animal life, by a very natural error, was originally supposed to be marked out by the quality of locomotion; but that, we now well know, is not extended to the meanest order of animals; and, therefore, cannot be invested with such undue significance. Nor am I inclined to adopt the modern distinction of Sensibility; for many plants, from the delicacy and peculiar character of their organization, are largely endowed with this quality, while some of the inferior animals have scarcely any. In fact, I think the only barrier which can be recognised with safety or propriety is Volition. The very lowest order of beings, as an essential condition of animal life, are endued with volition, though destitute of that nervous influence which, after forming so prominent a characteris-

tic of the higher groups of animals, reappears in the world of plants. That some degree of volition is indispensable to an animal, no one can doubt; and that sensibility is exhibited by certain tribes of plants, in a manner both curious and impressive, is indisputable. As an instance, I need only mention the Desmodium gyrans, which combines sensibility with motion. These two qualities, moreover, are spontaneously exercised, and are not the effect of an external stimulus. The leaflets, paired laterally beneath a large terminal leaf, alternately incline up and down, changing one movement for the other as soon as they attain a certain elevation or depression; and this oscillation, performed with such beautiful regularity, is shared by the terminal leaf, which has a corresponding range of inclination, and moves up and down in a similar way.

The plants which shrink from the touch are pretty generally known; but the degree in which this sensitiveness is developed, in certain individuals, is not so well understood. The concentration of the sun's rays, through a common

lens, on the Mimosa pudica, will cause a singular commotion of its leaflets, and it has been ascertained that the power of motion emanates from joints at the root of the leaf; but though the medium is apparent, its mode of operation, by which the elastic texture of the joints is brought into play, defies detection. Until these minute arcana are unravelled, it cannot be expected that the great distinctions between plants and animals will be universally and satisfactorily settled.

But the organization of plants, designed with such exquisite skill, is not more wonderful than their dispersion, and the simple means by which that effect is accomplished. Here we see the Almighty carrying on the great operations of nature through agencies of the humblest description, involuntary instruments of His will. In many cases, fruits and vegetables, containing aliment indispensable to animal life, have the power of dispersion vested in themselves, and become the disseminators of their own seed. In the pseudospermic family, including the parsnip, carrot, and other edibles, this is espe-

cially manifest, and some of the pseudospermic seeds are winged with down, which, being caught by the wind, greatly facilitate their diffusion. The seed-vessels of some of the capsular fruits, such as the balsams, are so constructed, that when the imprisoned seed attains perfection, they rend abruptly asunder, and the shock ejects the precious contents a considerable distance. The seeds of some other species fall, when ripe, immediately under their parent, and either spring up in the adjacent soil, or are blown along by the wind to a less crowded location. Those of pulpy fruits, which are inclosed in a nut, or stone crust, to preserve them from the corrupting moisture of the pulp, by which they would otherwise be destroyed, are disseminated by animals, being swallowed unconsciously in the fleshy portion, and then passed in their stony envelope through the digestive organs without injury. In many cases, the beasts of the forest, lying down where they have fed—perhaps under the shade of an umbrageous tree, which is at that moment shedding its produce—pick up seeds in their

shaggy coats, and convey them to spots previously sterile. Birds also are instrumental in their dissemination, and like the larger animals, eject them in a state peculiarly suited to vegetation. Winged seeds being easily disseminated by the air, are not dependent on accidental influences, but, under certain circumstances, will cross seas and vast deserts on their own filmy pennons, searching for a genial soil. Less buoyant, but not less intrepid adventurers, coated in impervious husks and pulps, or perhaps still lodged on their parent branch, are swept from the regions of their nativity by brooks and rivers, and deposited unimpaired in new and remote situations.

But while we are struck with wonder at the efficiency of this natural provision for dispersion, and admit also how signally it has been aided by the enterprise and industry of man, it by no means follows that we should assume, with the disciples of Linnæus, and the theoretic philosophers of the day, that plants have all emanated originally from one particular region. On the contrary, the infinite variety of species, requiring

such endless differences of temperature, makes it abundantly clear that they could never have been thus restricted, but must always have been dispersed pretty equally over the world. Indeed, seeds have sometimes been found by persons excavating shafts and tunnels, buried deep in the earth, being, by some condition of the soil, prevented from germinating, and on removal to other beds, have sprung up and flourished. This would indicate a primeval distribution, which best accords with the grand scheme of the Creation; and certainly the idea of a botanical Eden is unsupported either by reason or Revelation.

Modern science has established beyond doubt, by experiments of the most decisive character, that the numberless species of plants now in existence, are essentially independent and distinct. It is found that the vicinity of the equator is favourable to Dicotyledons, and embraces in its flora the greatest number of species, while temperate latitudes, in proportion as they are removed from the great central line, cherish the cryptogamic species. All species are classed into three divisions, called Primary,

and bearing the several designations of—1, Dicotyledons, or Exogenæ—2, Monocotyledons, or Endogenæ—and 3, Acotyledons. The two first are also called phanerogamic, or flowering, to distinguish them from the Acotyledons, which, as a flowerless species, are termed cryptogamic. Linnæus, the legislator of plants, has divided these three groups into twenty-four classes, of which twenty-three are Dicotyledons and Monocotyledons, and only one Acotyledons. These are again divided by characteristic distinctions, resting on certain peculiarities of structure or organization, into minor groups, called genera; and a further division is sometimes effected, when the appellation of sub-genera is applied. The term "race," which is so commonly used, denotes a variety well-distinguished from the parent stock, and capable of reproducing itself.

The first primary division of the botanical kingdom, which derives its name of Dicotyledons from the structure of the seed, and its appellation of Exogenæ from the habit of enlarging the stem by external additions, is

composed, with comparatively few exceptions, of those plants whose embryo is formed of two Cotyledons,—soft lobes, consisting of two undeveloped leaves, held together by a diminutive germ, which they scarcely suffer to appear. When the plant germinates, the Cotyledons, relieved from restraint, open into two distinct leaves, which, however, never attain perfection. Other embryos of this order are encrusted with albumen, and hence derive strength and nutriment during the helpless period of infancy.

Monocotyledons, whose alias of Endogenæ denotes that the accessions to the stem are developed inwardly, are not so broadly marked in their embryos as the Dicotyledons. Their solitary Cotyledon, which emanates from one end of the embryo, is conical in shape, and as it matures, discloses a rolled leaf, which makes its appearance in a corresponding form. The other end of the embryo is furnished with a radicle.

Acotyledons, or flowerless plants, do not yield seed, but reproduce themselves from

sporules, little granular spheroids, inclosed in superficial cells, or lodged in the interior of the plant.

Plants have two series of organs:—the one composed of those which, carrying on the structural functions, secure it a proper supply of nutriment; the other consisting of the organs of reproduction. They have also two tendencies, adapted to the opposite characters of different organs, and from a certain point in the stem, designated the neck, the development of one portion is downwards, while the other shoots upward.

The internal structure consists of an accumulation of cells, formed of tissue, which is hence called cellular tissue, and traversed by tubes of a similar material, called vascular tissue. Many inferior Acotyledons, however, are composed wholly of the former texture, without any admixture of fibre. In the other classes, the cells, which always greatly predominate, are generally polygonal in shape, and the tubes cylindrical; and little perforations in the cells afford a passage of communication

from one cell to another. Through this channel, answering to the arteries of animals, flows the sap, though botanists are not agreed as to its mode of progression. It ascends from the root to the leaves, where, by contact with the atmosphere, it is converted into carbonic acid, the fluid best adapted at the moment to the sustenance of the plant, but which, under the action of light, ultimately decomposes, and becomes a fixed compound. The first change is accomplished by respiration; when the air, mainly inhaled by the leaves, is introduced into the stem, and becomes an active agent in the organic economy. A nutritious alimental juice, derived from the decomposed sap, is now diffused through the structure, and imparts vigour to all its organs. This is, in fact, the blood of the plant, circulating in its veins!

Plants are, for the most part, covered during the period of development by a fine thin network, or skin, called the epidermis, which is generally porous, sometimes presenting the appearance of scales, or seeming to be coated with bristles or hair. The pores, which bear the name of

stomata, are created by a combination of vesicles, in form resembling a crescent; and the attached particles are vesicles of various shapes, differing in this respect according to the character of the plant, but all composed of cellular tissue.

The primary nutritive organs, indispensable to the existence of a plant, are the root, the stem, and the leaf. The root, as the source of life, usually constitutes the lower extremity, and secures itself in the soil by branches, or fibrils, traversed by ducts, and terminating in uncovered cellular points, called spangioles, which perform the function of absorption. Such roots are developed from seed, but in many cases roots are derived from the stem, or from cuttings, and some tropical plants, as the barba-dos of the West Indies, produce roots from their branches, which drooping down, fix themselves in the soil, and start up as independent plants, expanding their magnificent foliage in the arms of the parent tree. Some aquatic plants, dependent on atmospheric influences, have their roots furnished with air-

bladders, which float them on the water, and so secure the position necessary to their existence. In crossing the Grassy Sea, I fished up some of the floating weed, and found it was sustained on the surface, amidst the fury of the roughest billows, by little bladder-like vessels, filled with air, which defy the violence of the ocean. To such minute objects do the overruling care and providence of the Almighty extend!

From the root proceeds the stem, the tendency of which, be it remembered, is to shoot upward. In the lower plants, indeed, the stem is but slightly developed, though generally by far the largest organ, and known, according to the character of the plant, either as the trunk or the culm. Pith and bark are prominent ingredients in the stems of dicotyledonous trees, in which medullary rays, the nerves of the wood, are also conspicuous. The stems of monocotyledonous trees, usually the produce of warm climates, are, with some few exceptions, nearly cylindrical in shape, and, though most frequently bare to the top, are

crowned with a mass of exuberant foliage, by which the long naked stem is nourished and sustained.

The stem gives birth to the buds, minute and delicate germs, formed of several folds of embryo leaves, carefully protected by textures varying with the genus of the tree, from any adverse influence of the atmosphere. These burst into shoots, which, gradually maturing, advance into branches, corresponding in organization, and in their internal economy, with the stem, of which they are at once the offspring and the support.

The branches are clothed with a rich mantle of leaves, generally periodic appendages, falling off in the autumn, and reappearing with the spring, though the family of evergreens retain their verdant robe through the nipping frosts of winter. Leaves are composed of a number of veins, traversing an expansion of cellular tissue, covered with epidermis, and are either perfectly flat, or slightly curled. The veins, called from their function the nervation, meet at the peticle, or leaf-stalk, whence, concentrated in one line,

they proceed together to the expansion, or limb, and then, again dividing, are distributed in various directions, ministering to the wants and the tendencies of the plant.

Flowers, the gems of vegetation, which charm the eye with their brilliant hues, and fill the air with delicious odours, germinate in a manner similar to the leaf-bud, and are, in fact, a modification of the same class of embryo. In this case, however, the function attached is not nutrition, as in the leaf, but reproduction. A flower, as it becomes developed, is found to consist of a series of whorls, rising from a torus, or receptacle, and inclosing the fertilising organs, essential to the perfection of the seed. The number of whorls varies with the character of the plant—some plants having their whorls divided into four distinct organs, while others comprise only one. This, which is the source of reproduction, must be either the stamens or the carpels—the two inner whorls, surrounded, in plants endued with the larger number of organs, first by the corolla, and afterwards by the calyx.

The odours of plants emanate from a volatile oil, secreted, by some process yet undiscovered, in the stalks and leaves, and diffused from flowers by the action of the atmosphere. The scent emitted is not always agreeable, and in a few cases is even excessively offensive; but nature, with the discrimination apparent in all her works, has made beauty of form and colour an almost certain pledge of the sweetest of odours.

The commencement of decay in the external parts of the flower, not connected with the functions of reproduction, announces the germination of the fruit. The receptacle of the seed, at first designated the ovarium, continues to grow, and is gradually converted into a pericarp. This is composed of cellular matter, called sarcocarp, enveloped in two coats of skin, the outermost of which, usually the most perfect, is named the epicarp, while the inner bears the appellation of endocarp. It is the endocarp which, in certain kinds of fruit, becoming more and more developed, ultimately takes the shape of a heart of stone, imbedded in the soft, fleshy,

pulp of the sarcocarp, which forms the nutritious and edible part of the fruit. The latter, as it continues to mature, absorbs the alimental liquid circulating in the branches, and thus becomes pervaded with delicious juices, derived from every portion of the tree. In succulent fruits, these distillations consist chiefly of water, mingled with gummalic acid, colouring ingredients, and malate of lime; and the pulpy matter, of lignine. Colour, as in flowers, proceeds originally from the internal secretions, and is rendered more prominent and distinct by the operation of light.

The process of reproduction in plants approximates closely to that of animal gestation. Though in some cases superseded by cuttings, the natural course of propagation, as I have before intimated, is from seed, developed under sexual influence. The distinctive organs are the stamens, which represent the male, and the carpels, or female; and each, as a special appendage, is surrounded by a whorl, occupying the centre of the bud. The stamens are an aggregation of silken stems, each supporting two small oval tubes, or cells,

termed anthers, which are charged with pollen, a fine powder, essential to fertilization, and this, when matured, escapes through a puncture in the anther, and is discharged on the seed. The seed, as the germ of reproduction, is lodged in the carpels, which, like the stamens, comprises two divisions—the ovarium, or receptacle of the seed, and the stigma, which forms the vehicle of communication. Acotyledons, or flowerless plants, having no actual seed, propagate their species by means of sporules, a substitute every way efficient, and bearing a striking external resemblance to the bodies they represent.

It is unnecessary to follow out this section of the subject in its bearings on hybrids and varieties, and thus show more fully, by other examples, how close is the analogy between the vegetable and the animal kingdoms. Enough has been said to demonstrate, to the most sceptical and unwilling minds, that the similarity is real and inherent, and that the same mysterious principle of life, which baffles research in the highest orders of animals, is

no less occult, no less unsearchable, in the meanest and most insignificant plant. We penetrate the structure; we unveil the wondrous and beautiful mechanism, we behold and participate the existence; but what, in all this grand series of agencies, is the pervading but invisible property by which we have our being? That indeed is a question which Science is unable to solve!

The rapid outline I have given of the economy and characteristics of plants, as evinced in their organization and structure, admits of but one conclusion—namely, that the floral world is manifestly the work of an all-wise and all-powerful Creator. In the whole of this mighty scheme we find nothing left to accident or chance, but every development, in its most minute and most insignificant details, foreseen, predetermined, and settled. Plants do not—as a recent publication would have us believe—grow spontaneously; but they spring from seed, and that seed is the ova of another plant. It gradually breaks into life, develops its various organs, and takes, not a capricious,

but a certain fixed and defined form—the form of its parent. Its existence does not depend, as the sceptical philosophers insist, on accidental influences of temperature, but on established and immutable conditions, directed and perpetuated by fundamental laws, which, in their universal operation, embrace at once the greatest and the meanest objects. Attaining maturity, it becomes itself a parent, and the species is continued in its progeny.

Such are the works of God! We are told, as much for our admonition as our learning, that even the countless hairs of our heads are all numbered: and does this seem impossible, when we find that the minute bristles and shadowy down of plants, though perhaps invisible to the unaided eye, are measured out with no less forethought, discrimination, and precision? The fact conveys its own lesson; and in the amazement it inspires, we instinctively recal the devout words of the Psalmist—"Such knowledge is too wonderful and excellent for me: I cannot attain unto it."

XII.

THE ANIMAL KINGDOM.

The beautiful arrangement and admirable completeness of the botanical kingdom, showing at every point such obvious evidence of design, and so marked an adjustment of conditions and capabilities of being, prepare us for the more wonderful revelations of the animal world, which, ascending successive steps in the scale of nature, forms a connecting chord between the Creation and the Creator.

I have already pointed out how intimate are the relations of the two kingdoms, so that, in a manner, each runs into and blends with the other, as if the frontier tribes on either side

combined the characteristics of both. And this close and indivisible fellowship, instead of producing confusion, is a link in the grand scheme of universal harmony, without which it would be broken and imperfect. But, however imperceptible, a chasm must somewhere exist, as the distinction, when developed, is wide, decided, and real. It is, in fact, the difference between still and active life, a passive and an impulsive organization. The vital principle, hitherto merely rudimentary, now becomes perfected, and assumes a new range of tendencies and functions. The marvels of this enlarged and more complex mechanism surpass the reach of imagination, and baffle the penetration of the most subtle minds. Long and closely as they have been investigated, every day proves, by some accidental discovery, that the observations which naturalists have so jealously hoarded are bald and meagre, and our knowledge of the subject superficial. We see enough, indeed, to trace in each organization, and every successive grade, the constructing hand and over-ruling wisdom of the Creator; but how much remains that,

after exerting all the appliances of Science, no eye can search out! Well may the Apostle exclaim, "God hath chosen the foolish things of this world to confound the wise; and the weak things of the world to confound the things that are mighty."

Nowhere can we find a more elevating pursuit than the study of animated nature, yet, from perpetual familiarity, mankind, with a few isolated exceptions, regard it with indifference or neglect. We listen enraptured to the tuneful voices of the birds, as they fill the woods with their melody; but not many pause, with the naturalist and the philosopher, to inquire into their habits and instincts. The wisdom and forecast of the bee are a proverb, yet the fact that so minute a creature, with a vocation apparently so humble, continually exercises these great and sublime faculties, excites neither curiosity nor wonder. Even among those who are arrested by the spectacle, few search its less prominent details for a vestige of its Author.

The commanding genius of Aristotle, which pushed its researches into every department of

knowledge, could not overlook a subject so rich in moral and scientific interest; and accordingly we owe to the mighty Stagyrite the first rude outline of zoology. But groping in the dark, it was natural that, as he advanced on his unexplored way, the sage should unconsciously deviate from the right path, and be led into conclusions at variance with truth. Indeed, the accumulated investigations of two thousand years, including the labours of a Buffon, a Linnæus, and a Cuvier, have brought us only to the threshold of the Science, and we still see a boundless expanse before us, scarcely broken, at wide and uncertain intervals, by a few flickering beacons, which lend no light to our steps.

Animal life, as at present defined, commences with the Infusoria, bodies so small as to be only perceptible with the microscope, but which are endued with surprising vitality and fecundity. Some species, indeed, possess a structure that, at first sight, would seem to belong to a more elevated grade, although, in point of fact, peculiarly adapted to their position. The Botifera, or wheel-insects, are the most highly organized

of these invisible monsters, having a mouth, a stomach, an intestine, an anus, and a tail, while the neck, examined through a powerful microscope, appears to be furnished with eyes, and anteriorly it bears a most curious organ, the denticulated edges of which vibrate in succession, giving the whole member the aspect of a revolving wheel. The Fercularia, which were subjected by Spallanzani to a series of ingenious experiments, are chiefly remarkable for their extraordinary tenacity of life, to which they may be recalled by a drop of water, after the vital principle has been for some weeks extinct. In the second order of Infusoria, called the Homogenea, we find the genus Vibrio, which embraces two sexes, and produces, at different seasons, both a living progeny and eggs. The Proteus is perhaps the most wonderful genus of all, as it is perpetually changing its shape, and rarely preserves the same form for two moments together. Another genus is remarkable for its mode of propagation, which, in opposition to all the uses of nature, is by subdivision, each discarded particle assuming the figure of the

parent, and becoming immediately a perfect and independent being.

From the Infusoria we ascend to the Zoophyta, or radiated animals, a class in which they are generally included, although, as will be seen, their organization is in many points different. They derive their name of Zoophyta, or animal plants, from the radiation of their organs, which thus bear a resemblance to the petals of flowers; but the individual is, in all respects, an animal, possessing, in conjunction with the minor faculties, the distinctive quality of volition. The sexes, as might be expected in such a low condition of life, are not always visible, and in some orders, are wholly wanting; propagation being effected by division, or by germination. Most frequently there is no nervous system, and when apparent, it is disposed in radii, and is both feeble and imperfect. Indeed, the organization in general, though varying in degree according to the habits and requirements of the genus, is essentially rudimentary, and marks unmistakably the first faint pulse of existence. The Holothuria, of the order of

Pedicelluta, have their oblong, coriaceous body traversed by an intestinal canal, open at each end, and embracing an intricate and duplex system of vessels, which present an appearance of circulation. Many genera, however, have but an intestinal sac, or stomach, furnished with only one aperture, and this serves for both mouth and anus. The Polypi, forming the fourth class of the group, show so little trace of animation, that they were for a long time considered to be stone plants; and not much more than a century has elapsed, since Imperati, by his indefatigable and elaborate investigations, established their claim to animal rank. The bodies of this class, varying in shape with the genera, are either cylindrical or conical, enveloping a cavity, and sometimes a visible stomach, where they are penetrated by intestinal vessels, which, linking both, probably serve as ducts to the central excavation. Propagation is effected both by ova and buds, and on a scale so stupendous, that Polypi become, in the slow cycle of ages, the architects of promontories and islands, founding new territories for the

residence of man. Lamarck has even conjectured that they constitute the whole of the calcareous strata of the world; but this, like other assertions of the same author, may reasonably be doubted.

Spongia, or Sponges, of the order of Corticati, are the humblest form of animal life yet discovered; and have only lately been raised to this rank, having been classed by the early naturalists in the catalogue of marine plants. Their vitality appears to be lodged in an adhesive gelatine, and is evinced by excessive sensitiveness, and by respiration. They supply themselves with nutriment, an important animal function, through their pores, which have been observed to imbibe sea-water by expanding, and to eject it, when its ailment was extracted, by the counter-process of contraction. Pores are very conspicuous in the common sponge, in such general and familiar use, and intersect each other in every direction, providing alike for the beautiful functions of nature, and for the purposes to which the animal is devoted by art.

Zoophytes, as a class, are but sparingly endowed with locomotion, and many genera may be said to be wholly deficient in this faculty, possessing freedom only in their arms or feelers, which, by seizing objects as they float past, secure them an abundant supply of aliment. Generally they are enchained by stems, or fixed immoveably to rocks; but even then, so essentially are they distinguished from the world of plants, the power of motion is vested in certain members, and evident in the meanest organization. The Actinia, a species of Polypus, are furnished with a number of tentacula, disposed like the petals of a double flower, whence, indeed, the animal take its ordinary name of Sea-Anemony, and, in changing their position, they use their tentacula as feet, and thus impel themselves along. The voracity of these little creatures is amazing, and with the aid of their tentacula, which surround their capacious mouth, they will frequently seize small fishes, of much greater dimensions than themselves, and gorge them without injury. Even Sponges have been seen to move, though it may be con-

cluded, as a general principle, that their freedom of motion is very restricted.

The step from the Animalia Radiata to the Articulata, which compose the next great division of the animal kingdom, introduces us to a wide range of beings, differing materially in detail, but all marked with the distinguishing characteristic of articulation. The rude forms of life gradually fade in a more complex structure, adapted with unerring precision to particular conditions and habits, embracing the whole existence of the individual. The little creature is thus enabled, by its wonderful and intricate organization, to meet every contingency that, in the natural course of things, it can possibly be exposed to, while, on the other hand, a directing influence within restrains it to its specific destination. Here the light of instinct breaks, like the first dawn of reason, through the inscrutable mystery of being, and even attains its highest development in some of the minutest insects. The more we contemplate it, the more we find to examine, while we are continually arrested by its marvellous effects. Here we behold the

tutelary control of an overruling Deity, displayed in the meanest of his works, and involuntarily recal those memorable words—"Are not two sparrows sold for one farthing; and not one of them is forgotten before your Heavenly Father!"

The Articulata, thus signally endowed, are divided by Cuvier into four grand classes, comprising various orders, which are subdivided into a number of families. The classes are severally designated Annulata, Crustacea, Arachnides, and Insecta.

Insecta, as the lowest class of the section, from the next superior grade to the Zoophyta, and thus have the first claim on our attention. It would be impossible, however, in the limited space to which my observations must be confined, to do more than glance at their principal and distinguishing attributes; for volumes have been written on the habits and endowments of insects, without in any way exhausting the interesting and fruitful subject. The bee alone, in its wondrous instinct, its refined communism, and its provident and untiring industry, presents a study worthy of the noblest minds.

Bees are even supposed to be endued, to a certain extent, with a faculty equivalent to speech; and on the abstraction of the queen, those sensible of the loss have been observed, in traversing the hive, to cross their antennæ over any of the community they may encounter, and strike them gently, on which, as if apprised of the disaster, the animals which receive the communication hurry away in the greatest uneasiness and alarm. Nor should we pass over their power of discerning any approaching alteration in the weather, so essential to their peculiar avocations, and by which they ascertain, more surely than the best instruments of science, that a shower is at hand, and hasten to seek the shelter of home. Other insects are endowed, in various proportions, with gifts equally estimable, and adjusted in a singular degree to the range of their requirements. All are invested with the five senses, though not to the same extent, as many, to qualify them for their particular mission, possess them in a high degree. The sense of touch, deposited in the antennæ, is almost universally of excessive deli-

cacy, and in the case of the spider, has been forcibly described by the pensive muse of Cowper:—

> "The spider's touch, how exquisitely fine,
> Feels in each thread, and lives along the line."

Insects are largely endowed with the faculty of sight; for their eyes, though unable to turn, are infinitely multiplied, and compensate by quantity for their want of motion. To give an idea of the numbers some orders possess, I may mention that one species of butterfly, by no means among the largest, is allotted nearly 35,000 eyes. These are distributed over every part of the body, and thus, whatever may be the position of the animal, no danger can approach unperceived, as a sentinel keeps watch in every quarter.

The passions of love and fear, and sometimes higher emotions, are exhibited very signally in some orders of insects, and are even expressed in sounds, which, while not without significance to the human ear, are doubtless full of meaning to themselves. The fact may be demonstrated

by giving chase to a common blue-bottle, which will immediately raise its note in a surprising manner, the tone being one of unmistakable alarm. In tropical countries I have noticed the same peculiarity, with but little variation, in mosquitoes; and the adroitness with which these little janissaries avoid capture, indicates an organization still more subtle.

Few are unacquainted with the alertness or the ferocity of spiders, exhibited so constantly within the sphere of familiar observation. Let a fly be thrown on a spider's web, and a strange spectacle will follow. The terror and despair of the fly at the first approach of his inexorable enemy—his energetic efforts to escape from the tyrant's clutches, and his last touching death-struggle, with the exultation, rage, and malignant cruelty of the spider, are a vivid mimicry of the mightier paroxysms of man, which few will be able to contemplate with apathy or indifference.

I need not dwell here on the affection of insects for their progeny, as that is a passion which, by the wise providence of the Almighty,

prevails, with few differences of degree, throughout the whole scale of nature. But it would be an omission not to say, that they experience more than usual difficulty in providing for the necessities and requirements of their young, yet pursue this object, under every disadvantage, with unwearying forecast, tenderness, and perseverance.

Insects, as a compensation for the brevity and precarious tenure of their existence, which is exposed continually to a thousand dangers peculiar to their particular condition, are endued with an extraordinary tenacity of life, surpassing that possessed by any other order of creatures. Many will fall from great heights without receiving the least injury, and others, more invulnerable still, may be stripped of their legs and wings with apparently the same result. Some will even survive after being cut in two, each fragment exhibiting an equal degree of vitality, and not a few seem to retain the vital property after all trace of it has disappeared. One fine winter morning, the sun, with an unseasonable exertion of power, pouring a flood

of warm and dazzling beams on the window, I observed several flies lying among a heap on the frame suddenly evince signs of life, and in a few minutes they were feebly crawling over the glass. As I looked on, the genial sunshine gave every moment fresh strength, though they did not, as I expected, acquire any lasting accession of vigour. It was the dream of summer that had burst the cerements of their long sleep, and the little glow of life went out with the syren sun.

In this wondrous vitality we behold another wise provision of the great Author of being, measuring the endowments of the creature with such marked regard to its especial wants, and to the influences to which it is exposed. Nor must I neglect to remark, that the same merciful dispensation, mindful of every contingency, has happily withheld from insects all sensibility of pain, thus rendering the contusions and mutilations to which they are so perpetually and unavoidably subjected utterly innocuous.

Insects form the chief aliment of the Arachnides, the next superior order of Articulata, which,

seizing them alive, either devour them bodily or draw out their fluids by suction. Some, however, will eat only vegetables, and others feed on vertebrated animals. Their organization, viewing the class generally, is especially adapted to subsistence by suction, the mouth being furnished with two pointed blades, used as lancets, and constructed to act as a sucker. They are not, like insects, provided with wings, but possess moveable legs, united by a segment to the abdomen, and usually terminating in two, and sometimes three hooks. Their form is not liable to change, nor do they undergo metamorphosis, but at certain seasons they cast their skin, and relieve themselves by this effort of what must otherwise have been fatal to their existence.

Arachnides and Insects have been grouped by Linnæus with the Crustacea, and the three classes received from the great philosopher, whom Science invested with the mission and authority of Adam, the general name of Insecta. But as Arachnides differ from Insects, so do Crustacea, as a more perfectly organised class,

claim superior rank to Arachnides. They are usually encased in a solid calcareous skin, perforated by openings, through which they receive and exhale air, and do not attain maturity, according to the observations of the most experienced naturalists, till this envelope has been several times cast. Like the order immediately below them, however, they are not subject to any mutations of form, only enlarging their proportions as they become older, and in some cases slightly modifying, while in others they increase the number of their locomotive organs. Their development is gradual and perceptible, covering a considerable period, and they enjoy an existence of several years. As a class, they are carnivorous, and their condition and habits are aquatic.

The Annulata, which are the class above the Crustacea, complete the articulated group, and are the only invertebrated animals furnished with red blood, whence they have received from Cuvier the appropriate name of "Red-blooded Worms." The vital fluid circulates through their bodies in a double system of vessels, of

an intricate and complicated structure, interspersed with fleshy ventricles, which seem to fulfil the ordinary functions of a heart. The body itself, from one extremity to the other, is composed of a series of rings, in all respects perfectly similar, except that the head, formed by the anterior ring, is the chief seat of the senses. They have no legs, but rest on a number of sharp bristles, which answer all the purposes of articulated feet; and as the entire class, with the solitary exception of the earthworm, is aquatic, this structure is singularly suited to their condition. Cuvier divides them into three orders—the Tubicola, which inhabit tubes; the Dorsibranchiata, whose vessels, occupying the centre of their stem-like bodies, are somewhat ramified; and the Abranchiata, which have no visible organs of respiration, and are supposed by naturalists to breathe through the skin.

From the Annulata we advance into the second grand section of the animal world, classed under the general designation of Mollusca, and composed of creatures which,

differing mainly from both the neighbouring systems, have neither an articulated skeleton nor a vertebral canal. Their bodies, varying in size and form, are almost uniformly enveloped in a very sensitive skin, sometimes of a fleshy texture, and acquiring for certain species the appellation of "Naked:" and in other cases becoming so indurated, that the external development, incrusting the whole animal, is converted into a shell, and hence procures for the order the name of Testaceous. Their powers of motion are confined to creeping and swimming, which, however, they accomplish very slowly. Many have no articulated feet, and therefore can only propel themselves by contraction and expansion, a laborious and impotent process. For the most part, Mollusca have no organs of sight; but the Cephalapoda, forming the first and principal group, have both eyes and ears, protected, by adaptations to their peculiar condition, from all the injurious influences to which they are naturally exposed. Their body, which is of the customary soft texture, consists of a mus-

cular sac, and is surmounted by a well-developed head, thrown backward in swimming, and at other times carried beneath the body. From the head project arms or feet, of a conical shape, and used with equal effect both for adhesion and propulsion, fastening on stones and plants, their ever-accessible moorings, with great tenacity, or when required, moving freely through the deep. As a condition of their aquatic character, the Cephalapoda, most commonly living at great depths, respire through water, which, from the disposition of the branchiæ, finds its way into their sac-like bodies, and passes out by an anterior aperture. Being utterly defenceless, and constituting the prey of other inhabitants of the ocean, in every respect superior to themselves, they are provided by nature with an equivalent for their weakness in the shape of a colouring fluid, with which, when threatened, they blacken the water, and thus cut off pursuit. So true it is, that even the tiniest atoms are remembered before God, whose " tender mercy is over all his works."

Several bivalve Mollusca, as a necessity of

their peculiar structure, are denied the faculty of locomotion, and, among these, some naturalists reckon the common oyster, which is usually found adhering to rocks, or sheltered reefs, as if it were permanently stationary. It is now known, however, that oysters do possess the power of moving themselves, though in a very limited degree, accomplishing the object by squirting water from their shells, which, agitating the stream around, has the effect of propelling them forward. The muscle, another bivalve, moves itself with a sort of tongue, capable either of contraction or elongation, and used at once as an arm and a foot. The snail offers the most familiar example of locomotion among univalves, so abounding in our lanes and gardens, and being an object of daily observation from our earliest youth. This little traveller, who carries his dwelling from place to place as an indispensable item of his equipment, has no legs, but glides along on his belly, and when required, pitches his homely tent, like some weary Arab, at an instant's notice, adhering to any surface, whether rough

or smooth, with the greatest tenacity. To this, too, he retreats, when danger threatens, as to a tried and impregnable citadel, and there remains in safety till the peril has passed by.

Cuvier groups the remainder of the animal kingdom in one section, divided, however, by two essential distinctions, into viviparous and oviparous, which are again arranged in subordinate classes, differing in many important particulars. Of the Oviparous Vertebrata, the principal divisions are Pisces, Reptilia, and Aves.

Pisces include every species of fish, classed in two grand orders, the Acanthropterygii, or spiny-fins, and the Chondropterygii, or cartilaginous fishes. The first are by far the most numerous, and comprehend the greatest variety. Their bodies, shaped with especial regard to their aquatic condition, are protected by a coat of scales, and terminate in a tail, which, moving alternately on either side, is a most efficient instrument of progression. Indeed, the singular adaptation of form and condition which marks every individual group of the animal

world, from man to the meanest creature, is in none more strikingly or more beautifully apparent. The structure of the fish, through all the varieties of the group, is expressly and obviously designed, no less in its organization than in its relative gravity, for existence in water, and for the only mode of progression which that element admits of. The specific gravity of a fish, morever, may be regulated, in most species, by the compression or dilation of a pouch of air, lying directly under the spine, and by this means the animal may rise to the surface, or sink to any depth, as its will or its requirements dictate. Respiration is effected through the agency of water, which is swallowed by the fish, and, after conveying a supply of air to the blood-vessels, is expelled through branchiæ, or gills, on either side of the neck. Fins, depending from ossiferous rays, and used to facilitate and expedite swimming, furnish their bodies with rudimentary limbs, and complete the organization of these citizens of the deep.

Of all the inhabitants of the seas, the most

wonderful, perhaps, is the whale—the great Leviathan, made to take his pastime therein. Whales are frequently eighty feet long, and I have myself seen one which, measuring it by the length of the ship I was in, while it lay immediately alongside, could not have been short of one hundred feet. Yet these unwieldy monsters, who might be looked upon as the monarchs of the waves, are often a prey to animals very inferior in strength and size. One of their enemies is a small shell-fish, which, seizing a favourable moment, insinuates itself beneath their fins, where it feeds in security on the thick layers of fat, defying every effort to shake it off. But the most terrible foe of the whale is the sword-fish, at whose approach, in dread of the battle that must ensue, it exhibits an extraordinary degree of agitation, and endeavours to retreat in the opposite direction. Having no instrument of defence but its tail, the inoffensive monster is but ill-adapted for conflict, and the sharp, tooth-edged beak of the rapacious sword-fish, darting first on one side and then on the other, lacerates and mangles its

huge frame with impunity, dyeing the water with its blood.

The most fierce as well as most voracious fish, if we may rely on our present experience, is the shark, which sometimes approaches in magnitude to the whale, though I must affirm, for my own part, that the largest I ever saw did not exceed sixteen feet in length. The terrible array of teeth possessed by this fish renders it as formidable as it is destructive. These fearful instruments are arranged in six rows, in a wedge-like figure, and altogether are a hundred and forty-four in number. The voracity of the shark is well known; and sailors, who regard it as their natural and most relentless enemy, have strange superstitions concerning its instincts. I have myself observed, on several occasions at sea, that when any person on board the vessel has been suffering from sickness, a shark has invariably appeared, and attended the vessel for days together. This may have been accidental, but, happening more than once, it was a

coincidence that one could not but consider singular.

Equally marvellous stories are related of the dolphin, which, though not so formidable, is scarcely less voracious than the shark, and, from the extent of its depredations, is called the plunderer of the deep. By a wise providence, however, both the dolphin and the shark seize their food with difficulty, being obliged, from the peculiar situation of the mouth, directly under the head, to turn on their backs to bite, thus allowing the prey time to escape. But for this check, their united ravages would speedily depopulate the ocean.

I must not omit to mention the variations of colour in the dolphin, which, spite of the declarations of travellers, many naturalists still consider fabulous. That this finny chameleon, however, does actually change his hue, and in his dying hour, glow with a hundred beautiful tints, ought not to be disputed, and I must add my testimony that the statement is strictly true.

Not the least remarkable of the piscatorial tribes is the flying-fish, an aquatic Mercury, met with in great abundance in the Tropics. Some naturalists suppose, with a pardonable scepticism, that its alleged flight is a leap, extending only from wave to wave; but I have seen it fly at least twenty yards, and on one occasion, a full-grown flying-fish, nearly as large as a herring, alighted on the deck of our vessel, seven or eight feet from the water. The wing, therefore, must be endued with no slight powers, though some assert that it is very feeble, and regard it as a mere elongation of the fin. It is equally an error to suppose, that this little wanderer is subjected, more than any other inhabitant of the deep, to incessant attacks on its existence, pursued beneath the waves by the dolphin or the shark, and when it seeks safety in flight, becoming the prey of rapacious birds. What may be its troubles below it is impossible to say, but I have, in various voyages, seen hundreds of flying-fish, careering in gay squadrons over the deep, and in no case have I ever known

them to be assailed by a gull. It is, therefore, fair to conclude that they are not so terribly persecuted as we have been led to imagine.

From Pisces we ascend by an easy gradation to the section of Reptiles, which, when young, resemble fish in many important particulars. The Batrachia, constituting the lowest order of the Saurians, are born with the branchiæ and forms of fish, and several even retain the branchiæ on reaching maturity. Of this order are frogs, toads, salamanders, sirens, &c. But perhaps the most striking of the Saurians, as respects both size and structure, is the crocodile, an animal of amphibious habits, too familiar from report to call for description. This hideous monster, found chiefly in the rivers and swollen estuaries of Africa, is frequently from fifteen to twenty feet in length, and five feet in circumference. His body is encased in a most curiously-wrought skin, looking like a suit of armour—a purpose, indeed, which it most effectually answers; while it is endued with a strength and ferocity commensurate

with its formidable appearance. It is the enemy alike of man and beast, attacking the fiercest and strongest, as well as the weakest animals, and in every case achieving an easy victory. Being no less prolific than destructive, it would, if suffered to propagate without hindrance, overrun the whole earth; but it is wisely ordained that the eggs containing its offspring should be the favourite food of numerous birds, which hunt for them with the greatest avidity; and, to render the chance of attaining maturity still less, the progeny, after escaping from the durance of the shell, are frequently devoured by the inexorable parent. But notwithstanding its ferocity, the crocodile may be made subject to man; and in some kingdoms of the East, as Ethiopia and Siam, we hear of its being harnessed, like the tame elephants, to the triumphal cars of Kings, and driven peaceably through populous cities.

Of the serpent tribe the largest is the Boa Constrictor, which frequently attains a length of forty feet, while its girth, except at the extremi-

ties, is in proportion. This terrible king of monsters lurks in the dense recesses of tropical forests, where, when prompted by hunger, it preys on every animal that comes within reach. Fastened round the boughs of trees, it has darted on the unwary traveller passing beneath, and after crushing him to death in its folds, gorged him at a meal. In the same way, and with equal facility, it has attacked and killed the strongest animals, and then swallowed them whole. These unconscionable repasts are followed by torpor, and the unwieldy animal, buried in some inaccessible lair, then digests its meal, and awakes to feel once more the sharp pangs of hunger. Thus prompted, it glides cautiously forth, and every beast of the forest flies at its approach.

Much has been said of a mystic power in the serpent tribe, of rivetting their destined prey by the fascination of their gaze. That there is some foundation for such statements I can myself vouch, having a few years ago, while travelling alone in South Africa, personally experienced the feeling. I was sitting on a

most seductive, lawn-like patch of turf, when, happening to look up, I saw a black snake within a few yards, regarding me with a peculiarly fixed and steady look. There was an intelligence, a spirituality, in the reptile's gaze, that held me enchained, and my eye remained fastened on its large glassy orbs. It was not fear, but wonder, awe. In another moment it would probably have sprung upon me, but in that time I had collected myself, and being without even the defence of a stick, took care to remove beyond danger.

Aves, the community of birds, raise us from the forest and savannah, the haunts of the noxious and loathsome reptile, to the crystal regions of air. The feathered tribes form one of the most beautiful and striking features of the Creation. Their varied and often brilliant plumage, and infinite diversity of form and size and colour, with their peculiar powers of flight, often accompanied by the precious gift of song, combine, with their habits, instincts, and endearing associations, to render them objects of especial interest. Who has not been cheered

by their melodious notes, resounding like a song of praise through the glorious woods? Who has not felt the charm of their presence, when contemplating, with enraptured eye, the lovely face of nature? More especially are they harbingers of the gladsome season of spring, recalling by their notes, the pious and impassioned lyric of the royal musician of Israel—"The flowers appear on the earth; the time of the singing of birds has come, and the voice of the turtle-dove is heard in our land."

The chief of the feathered tribes is the eagle, called by the ancients the bird of Jove. The golden eagle, found principally in mountainous and thinly-inhabited countries, attains a stature of three feet and a half, and its wings often measure as much as eight feet. Of all animals it flies the highest, and is extremely difficult to ensnare. Its strength of wing and powers of flight are frequently alluded to in Holy Writ. Saul and Jonathan are described by David as "swifter than eagles." Isaiah, so fruitful of imagery, promises the faithful that "they shall mount up with wings as eagles." And a similar

allusion is made even by the Almighty Himself, addressing the perverse and rebellious Israelites—"Ye have seen what I did unto the Egyptians; how I bare you on eagle's wings, and how I brought you unto myself."

The affection of eagles for their young, which forms one of their most striking characteristics, is also noticed in Scripture—"As an eagle stirreth up her nest, fluttereth over her young, spreadeth abroad her wings, taketh them, beareth them on her wings." By such methods, the parent, for the moment forgetful of herself, teaches her little ones to fly, and accustoms them to soar to great heights. Their nests, built in towering cliffs, remote from the haunts of men, afford the helpless progeny a safe and inaccessible asylum; and it is the chief employment of the parent to supply them with food. If not disturbed, the eagle inhabits the same nest during the whole of its life, said to extend over a hundred years, and even then, if the general report is to be credited, it dies not of old age, but in consequence of its beak turning

inward on the under mandible, which prevents it from taking any food.

While the eagle soars to incredible heights, the ostrich, though furnished with wings, is unable to raise its bulky frame from the ground. The average weight of the ostrich is about eighty pounds, which, were flight one of the properties of its condition, would require immense strength of wing to sustain it in the air. But, though denied the faculty of flight, it possesses extraordinary swiftness of foot, and will outrun the fleetest horses. When running, its wings, instead of hanging useless at its side, are stretched out, and worked in a manner corresponding with the motion of the legs, materially accelerating its progress. The voracity of this strange bird exceeds belief; and, when hungry, it will swallow leather, hair, glass, stones, and iron, with equal avidity and relish. Its height, from the top of the head to the ground, is six feet, but from the top of the back it is only four; and, measuring the neck with the back, it is six feet long.

Among the warblers the palm is given to the

nightingale, the undisputed king of melody. This renowned songster, who fills the woods with harmony, arrives in England with the glad sunshine of April, and takes his departure about the middle of August. He is chiefly found in the south of England, and but rarely, if ever, visits Scotland or Ireland. The rich flow of music which, amidst the silence of night, sweeps in thrilling notes through the air, proceeds from the male, who, perched at some distance, thus addresses his mate, confined by maternal cares to the nest, and cheers her with his melting tale of devotion. The further the night advances, the clearer does his little voice ring out its lay, and full well she knows, from the marvellous force of instinct, that only the approach of danger will bring it to a close. Thus she is warned to prepare for flight.

The family of warblers is very numerous, and, according to Buffon, includes upwards of a hundred and fifty species. Of English songsters, the redbreast, perhaps, is—after the nightingale—the greatest favourite. Still its claims on our affection are not higher than those of the lark,

the sweet bard of morning, or of the black-cap, called, from the exquisite pathos of its notes, the nightingale of the north.

Birds, after extending through so many varieties. and ranging over such an endless diversity of forms, seem to be linked to the terrestrial animals by the Vespertilio, better known by the English name of bats. This family has some organs in common with Quadrumana, particularly the three sorts of teeth, and their fore-arms, represented by wings, have the same power of revolving. They are nocturnal, and their sight, if not imperfect, is very near, and of the same character as that of the owl. To compensate for this, their almost naked wings possess the sense of touch in such exquisite perfection, that even after losing their sight, they will guide themselves, solely by the impressions of the air, through dense and intricate thickets. In appearance, the body of the bat has great affinity to that of the mouse, and its wings, though carrying it to considerable altitudes, are bare of plumage, and consequently have but little resemblance to a bird's.

The highest order of animals is the mammalia, so called from their mammæ, or breasts, with which they suckle their young. Man, himself is included in this class; but as I propose to speak of him at length, in a separate chapter, I shall not enter on his history here, considering that such amalgamation is not only calculated to induce mistaken views, but is in itself a serious and fundamental error.

Mammalia are as remarkable for the completeness and intricacy of their structure, as for their superior faculties and endowments. They possess, consequently, a greater degree of intelligence than other animals, amounting in some cases almost to sagacity; and it is not always that their refined and acuter instincts can be satisfactorily distinguished from the operations of reason. The brain, which may be regarded as the most important medium of sensibility, preserves the same outline throughout the class, being uniformly divided into two hemispheres, linked by a medullary layer, inclosing the ventricles. Their lungs are duplex, and formed of lobes, and are lodged between the ribs and

diaphragm. Mammalia possess the five senses, so essential to their particular condition of life, in great perfection, and hence are most subtle in their habits, and adroit in resources. With a few exceptions, they are intended for walking on the earth, and their motions, varying with the character of the animal, are defined and regulated by the internal organization.

Of all animals, man alone excepted, the elephant is the most powerful and the most sagacious. It has been well said, that he combines the judgment of the beaver, the dexterity of the monkey, and the sentiment of the dog, while, in addition to these endowments, he possesses the advantages of strength and size. When brought into subjection to man, the docility of this huge animal is amazing; and he may be trained, as among the nations of India, to perform almost any service. He is endued with the faculty of memory in an astonishing degree, and displays so much moderation, gratitude, and fidelity in his attendance on man, that the ancients, misled by his demeanour, considered him to possess the moral virtues. He

is undoubtedly less the slave of impulse, and more courageous, prudent, and tractable than any other animal, seeming to be ruled by a principle approaching to consciousness. In the East, he is used in time of peace to swell the barbaric pomp of its effeminate satraps, and when hostilities break out, becomes a formidable arm of war. Bearing on his mighty back a battlemented tower, garrisoned with armed men, this Titan of beasts advances, with fearless step, to meet the shock of battle, and ploughs his way through serried battalions. The elephant attains great longevity, frequently living through two centuries, and, if the testimony of his Hindoo tamers may be relied on, retains his vigour almost to the last. His favourite haunts, when in a state of nature, are the glades of African forests, and the matted jungles of Asia; and in these sylvan retreats, he finds the grass and foliage which serve him for food.

One of the most singular orders of mammalia is the Marsupialia, or pouched animals, so called from a peculiar development of the skin of the abdomen, which forms a sort of pouch beneath

the mammæ. In this recess the progeny, brought forth in a rudimentary form, with their organization only imperfectly marked, are carefully and tenderly reared, and in moments of danger, they take refuge here, even after they are able to walk. The opossum, philager, kangaroo, &c., are of the marsupial order.

Quadrumana, or animals with four hands, approach nearest in anatomical structure to man. The class, though including numerous species, admits of only two principal divisions—monkeys and lemurs. The ourang-outang, or wild man of the woods, a native of the regions north of Coromandel, is the most perfect of the order, having neither cheek-pouches nor tail, and resembling man in the shape of his head, the quantity of his brain, and, according to some authorities, even in stature. The body of this satyr is clothed with hair; his muzzle is prominent, and his visage tinged with blue. In youth, he is docile and gentle, and may be tamed without difficulty. The Pongo, a variety of the species, found principally in Borneo, is said to attain a height of six feet.

The Chimpanzee, reputed to be the largest monkey in existence, is, if the reports of travellers are to be credited, superior in stature to the tallest man. These Brobdignagian monkeys are located in Congo and Guinea, where, mimicking the habits of the human population, they reside in villages of huts, constructed of leaves and branches of trees, and when molested, take up clubs and stones, and defend themselves with great vigour. De la Brusse, a French traveller, asserts that they frequently surprise and carry off the negresses, whom they detain as captives in their lairs, treating them, however, with great tenderness and consideration; but all these statements must be received with great caution, and most probably are mere inventions. Two young Chimpanzees are now in the Zoological Gardens Regent's Park, but at present do not approach the proportions assigned to their race.

Another large species of monkey is the mandril, which, like the ourang-outang, grows to the size of man. Of all animals this is the most revolting and the most hideous. His

muzzle is long, and seamed with wrinkles; his nose, which has some resemblance to that of a dog, is tipped with scarlet; and the rest of the complexion is blue. His face, so unsightly in form, is pierced by two additional nostrils, quite independent of the nose, and which exude a continuous stream of mucus, adding greatly to the horror of his appearance. This monster is very ferocious in his nature, and is much dreaded by the negroes of the Gold Coast, and the southern regions of Africa, where, with a number of other baboons, he roams unconstrained over the soil. It is said that he occasionally walks erect—a physical impossibility; and that he sighs and weeps like a human being.

In contemplating the spectacle presented by the animal kingdom, the feature which most excites our astonishment, above every other point of its marvellous details, is the wonderful and inscrutable property which governs the habits of each individual species, and to which we are accustomed to give the name of instinct. To this mysterious principle, we attribute every

variety of impulse, and every gleam of intelligence. So amazing, in some instances, are its operations, that it is difficult to say, at first sight, in what respect it differs from reason. Nor is it among animals of the greatest bulk, if we make the single exception of the elephant, that its overruling qualities are most apparent. The smallest insects acknowledge its power, and yield obedience to its dictates. It gives passions and desires to the invisible animalcule, and has won an enviable reputation for the bee. Guided by instinct, the white ant of Africa, perhaps the most ingenious of all insects, adopts a scheme of life and government, such as man himself may study with advantage, and can only regard with admiration.

The pyramids of the Pharaohs, those Alps of art, the most stupendous monuments of human labour and industry, are, comparatively speaking, not more colossal than the dwelling of this little architect, which he rears to the incredible height of twelve feet from the ground. This towering fabric is traversed by numerous tiers

of galleries, communicating with chambers and recesses, the life-long abodes of a busy and ingenious community. While the queen ant lives royally, though a perpetual prisoner, in the basement story of the structure, attended by sedulous courtiers, and surrounded by a guard of honour, restless artificers are engaged in constructing and tunnelling roads, and labourers bring in provisions, and distribute them to the consumers. Indeed, were I to set down all that is told of the white ant, and its wondrous and unaccountable faculties, I should seem, from the marvellous nature of the narrative, to be relating fables, requiring as wide a latitude of belief as those of Æsop. The facts, however, are well authenticated, and in all probability, were known to philosophers in the earliest times. The industry and providence of the ant, its two greatest characteristics, are indeed referred to very pointedly by Solomon. "Go to the ant, thou sluggard: consider her ways, and be wise: which having no guide, overseer, or ruler, provideth her meat in the summer, and gathereth

her food in the harvest." And again: "The ants are a people not strong, yet they prepare their meat in the summer."

What, then, is this influence, this divine and mysterious property, which governs and directs every irrational being? In what does it differ from judgment, from reason? How are we to separate the two principles, and allot to each its precise and especial dominion?

One thing seems clear, that if we invest any individual of the brute kingdom with reason, we must, as an inevitable consequence, extend the gift to every species; and it is equally obvious, if the matter is viewed in a candid spirit, that the moment an animal receives this endowment, he becomes a rational and an accountable being. Yet no one will be brought to imagine, by the wildest stretch of speculation, that a spider is responsible for its actions, or a tiger for its propensities. Their pursuits are shaped, not by themselves—not by a free and reflective capacity, but by a law of nature—by INSTINCT, from which all their impulses pro-

ceed. They are not unshackled and independent agents, but slaves.

We thus see that instinct is involuntary, and not governed by *will*. Its limits are fixed, and, whatever may be the condition of the animal, it cannot travel out of them. From age to age, under every variety of circumstance, it pursues the same beaten track, and never either retrogrades or advances. Instinct is an unerring guide, but it is a blind one.

On the other hand, the ruling faculty of reason, its most absolute and leading characteristic, is CONSCIOUSNESS—the knowledge of good and evil. It is not impulsive, but reflective—not inflexible, but yielding. In a word, it is an emanation of the Divine Intelligence, immortal and imperishable—the seal of God, stamping His image on the noblest of His creatures.

XIII.

THE RACE OF MAN.

THE head of the Creation is Man. Endowed with the greatest beauty of form, the noblest aspect, and an organization every way peculiar, he is designed by God to rule over all things, and to be an immediate reflection of His own image. As if to symbolise this pre-eminence, he is the only animal that walks erect, or that is invested, in compensation for physical deficiencies, with the sovereign attributes of reason.

The erect position is not only the most natural to man—the most becoming to his appearance, and the best suited to his habits,

but he could not, if inclined, move for any length of time on his hands and feet. In such a posture, the action of the heart, which is differently placed from that of other animals, would be impeded, and the whole circulation of the blood deranged. His eyes, being adapted only for looking straight forward, would be useless, as the head could not be sustained by the small indented muscle on which it rests, and keeping the line of the spine, would be continually bent towards the ground. Thus his majestic features would always be hidden, while his movements, instead of being remarkable for dignity and grace, would be ludicrously grotesque and clumsy.

On the other hand, his body is admirably formed for vertical motion, and, in this attitude, displays a singular combination of beauty and proportion. The feet, instead of resting on the outer edge, as with monkeys, have an expanded heel and almost flattened surface, supporting easily the whole weight of the legs. The toes are short, and not opposable to each other, so that, while no way adapted for climbing, they

are capable of great exertions on level ground. In the vertical position, too, the head sits lightly and gracefully on its sustaining muscle, and all the features of the face are fully displayed. The eyes have an uninterrupted sphere of vision, which, indeed, is all the more perfect from being concentrated in one direction, and the ease with which the head may be turned, as necessity or inclination prompts, enables them to overlook every quarter.

But with all his imposing appearance, and marked peculiarity of structure, man is physically the most helpless of beings. The skin which encases his frame, unlike that of other animals, is soft and delicate, and unprotected by hair. He possesses no instruments of defence, nor can he, without the aid of art, even supply himself with nutritious food, his teeth being formed only for grinding bulbs and roots, and not for masticating flesh. The extremes of temperature to which he is subjected in different regions of the globe—often indeed in the same—would be fatal to his existence, if he remained in a state of nature; and, instead of flourishing

in every latitude, he would be altogether swept from the earth. Nor does he possess the fine subtle instinct which is so unfailing a resource with the subordinate animals. In infancy he derives his nurture from his mother's breast, and for years is subject to her rule, and dependent on her care. Not till after a tedious education, acquired with difficulty and pain, is he fitted to take part in the pursuits of life, and to provide his own subsistence. Then disease attacks him in a hundred virulent and malignant types, and age, treading close on his prime, bends his worn and aching frame, and brings all his years to an end, as a tale that is told.

Such is the natural, inherent feebleness which forces man to look for aid to his intellect, and calls into constant requisition the divine faculties of his mind. These enable him, by their admirable contrivances, to cover and negative his defects, and turn his weeknesses into points of strength. The instruments of attack and defence so necessary to his safety, he constructs with his own hands; he clothes his delicate and sensitive body, exposed by nature to all the baneful

influences of climate, in sumptuous clothes, manufactured from the warm furs and skins of beasts; some animals he subdues to be creatures of burden, or humble ministers of his will; the flesh of others, prepared and rendered palatable by fire, provokes his appetite, and is made to furnish an inexhaustible supply of savoury and nourishing food. His weapons reach the wild game in the woods, and the bird in the air; his ingenuity and dexterity, stopping at no obstacle, draw the snake from his hole and the fish from the stream. He learns to till the earth, and reap its varied and delicious fruits; he digs in its mysterious depths, far removed from the light of Heaven, for useful and precious minerals, and makes them contribute to his wants, his comfort, and his luxury. As his knowledge and skill increase, mansions take the place of huts, and a city spreads its arms round the temple and the palace.

But it is not only in reference to the requirements and care of the body that our intellectual faculties are brought into play. These indeed form their first, but are by no means their prin-

cipal consideration. The whole scheme of nature, from the ground on which we tread to the remotest star of the firmament—every living creature, and every object, invites their attention, and affords them endless matter for inquiry. If we contemplate man in his original miserable condition, and then consider his present attainments in knowledge and science, his proficiency in the arts, and sublime achievements in literature—and bear in mind that all has been accomplished by his own unaided genius, we shall then admit that no miracle in nature is so wondrous and astounding. Driven by necessity to take counsel of his own mind, he has developed and enlarged its latent talents, and by every fresh invention, augmented its resources. His reason, his imagination, his searching investigations, and his mechanical skill, directed continually on new objects, have raised him immeasurably in the scale of being, and leave no limit to his progress. A time may come when his civilization will be universal, and then, if ever, wars will surely terminate, and nations live in security and peace.

While he is invested with divine intelligence,

man is endowed, in further token of his superiority, with a medium of inter-communication, by which he is enabled to convey his impressions and inmost thoughts to his fellows. The faculty of speech belongs exclusively to man, and is his master gift, giving form and expression to all the others. Indeed, it is impossible to estimate, in the ordinary compass of words, the blessings and advantages it confers upon us, or the sources of enjoyment it places at our command. In the accents of a Lind or a Kemble it becomes the very soul of music; a Brougham makes it the vehicle of the most impassioned eloquence; from the lips of a Siddons—when one rises to enchain our souls—it is equally sublime, touching, and persuasive. And, in the ordinary course of life, we derive from the power of speech every social and domestic endearment.

Man is no less favoured in the choice of his companion—WOMAN, in whom we behold the perfection of nature. What shall we say of an influence which is the mainspring of our existence, which animates every impulse, and shares

every hope of our hearts? The beauty and gentleness of woman—her tenderness—her devotion, her deep and holy affections, and the noble example of her endurance, have done more to humanize and elevate mankind, than all the inventions of genius, or all the revelations of science. Precisely as woman is appreciated, do we find á nation advanced in civilization and refinement. Among savage tribes, living in a state of the grossest barbarism—who eat human flesh, and sacrifice human beings to idols, she is a hewer of wood and drawer of water: by the effeminate people of the East she is degraded into a concubine and a toy; among the polite nations of Europe, she takes her proper place as man's companion and friend. Nor is the intellectual capacity of woman unequal to this position, or at all inferior to that of man. The mightiest kindgdom of the world, on whose territories the all-circling sun never sets, is proud to own the benign sway of a wise and gracious Queen, and history makes a boast of the great names of Semiramis, Helena, Catherine and Elizabeth. Heroism has its Zenobia, its

Boadicea, and its Joan of Arc. In our own day, a Somerville has solved the abstrusest problems of science; a Strickland has excelled in the field of history; a host of female names have won distinction in the arena of fiction; and a Landon, too soon snatched from amongst us, has touched the most plaintive chords of song. What more do we require to prove that woman is the equal, as well as the helpmate of man?

The whole human race is one family, and has sprung from one pair. The anatomical structure, by which distinctions of species are ascertained, is the same in all, and the differences of appearance are confined to complexion and the cast of the features. These are the effects of climate, developed and matured by a succession of generations. It has indeed been urged, that negroes having been in existence, as we learn from the sculptures of Egypt, as early as within four or five centuries of the Flood, such changes could not have been produced in so short a period, and, therefore, that either the black man must have had a distinct origin, or that there must be

some error in the Mosaic chronology. But notwithstanding all that has been said on the subject, by the most subtle and most powerful intellects, nothing has ever been advanced to shake in the least the authority of the Scriptural reckoning, and, indeed, the invaluable discoveries of Dr. Layard, at Nineveh, bear irresistible testimony to its correctness. The only question to consider, then, is, whether the interval was sufficient to give the Ethiope his skin, and produce those facial peculiarities by which he is distinguished. Few who have had experience of tropical climates will doubt either the adequacy of the cause, or the sufficiency of the time. Even in one generation, the children of European parents, born under a tropical sun, exhibit considerable differences of appearance, and the complexion of the Dutch boors, at the Cape of Good Hope, is but a shade or two lighter than that of the Indian. What, then, must have been the effect of climate on men living in a savage state, going about naked, having no dwelling but the bush, and no food but berries and wild fruit, or perhaps unwhole-

some roots? Continual exposure to the sun, in regions where its rays are most powerful, would naturally crisp and dry up the hair, and blacken the skin; and unrestrained indulgence in the animal passions would combine to distort and brutalize the features, and derange the organization of the brain. Nor must we forget that, in all probability, the original colour of the human complexion was not white, but dark, the tint which still prevails in the East, where the present race of men originated. In point of fact, therefore, it is not more difficult to account for the black complexion than the white; and that the latter is the effeet of climate, no one will venture to dispute. Indeed, it has been remarked, in the course of the recent Arctic expeditions, that the climate of the Polar regions exercises an immediate effect on the complexion, and a few weeks in the vicinity of the poles is sufficient to render the swarthiest face as white as snow.

The three principal varieties of mankind are the Caucasian, the Mongolian, and the Ethiopian. From these, as they spread into different

latitudes, sprang numerous offshoots, varying in tint and feature, but always preserving the distinguishing marks of descent. The Caucasians, or whites, form the noblest race, possessing the highest intellectual organization, and the most beautiful appearance. Cradled on the lofty heights of Caucasus, they early descended, with the simple habits of their native mountains, to colonise the fertile plains around, and gradually sought pasture for their flocks in more distant regions. While the Armenian families proceeded to the south, occupying Chaldea, Assyria, Egypt, and the wild solitudes of Arabia, the Pelasgic and Teutonic branches, more daring and adventurous, penetrated to the West, and founded the great nations of Europe. A few of the European families, indeed, appear to be of Mongolian extraction—for by such a supposition only can I account for the high cheek-bones and broad physiognomy of the Celts, though they have, I believe, always hitherto been classed amoung the Caucasians. The Caucasians have ever been foremost in the path of civilization, and have reached the

highest point of moral and physical excellence.

The Mongolians, or yellows, form the next great variety, and approach the Caucasians in intellectual endowments, though they appear quite incapable of attaining the same perfection. The Chinese, the most unique of nations, are of this race, and probably were the first to acquire a knowledge of learning and the arts. But these pioneers of civilization reached only the borders of the land of promise, and have ever since sojourned in the desert. In the late war with England, they displayed a degree of puerility and impotent cunning, joined to cowardice and treachery, such as could hardly have been expected from the most ignorant savages, and which was strangely suggestive of the infancy of mankind. They unquestionably possess, however, many rare qualities, which, under proper direction, may lead to great results, and obtain for them a prominent place among the nations of the earth. In California they have been conspicuous for industry, tact, perseverance, and ingenuity;

and are likely to prove equally useful in Australia. The great wall which divided them from their fellow-men, as effectually as the gloomy Styx, is now demolished, and they swarm from their hive in countless thousands, to populate and fertilize hitherto unpeopled regions. Who can say that they have not yet a mission assigned to them in the development and regeneration of the world?

The Calmucs are another powerful branch of the Mongolian family. The Bedouins of the East, they occupy, in restless hordes, the vast deserts of Tartary, where they are constantly wandering to and fro. More than once, they have poured from these wilds in overwhelming numbers, and ravaged the neighbouring territories with fire and sword. Tamerlane, the most heroic of their chiefs, subdued the haughtiest kingdoms of Asia, and Attila led their conquering hosts to the gates of imperial Rome. They still retain the courage of their ancestors, and are the terror and scourge of the effeminate Chinese.

The Mantchures, the Japanese, the Carcans, and the Malays are also of Mongolian origin, and, judging from their high cheek-bones and broad features, the Samoiedes, Ostiaks, Esquimaux, and Laplanders, who inhabit the northern regions of Asia and Europe, spring from the same stock. The Indians of America probably found their way to that continent from Siberia, with the inhabitants of which, as recent travellers inform us, they have many points of resemblance.

The third great division of the human family is the negro, or black, distinguished by his complexion, thick lips, flat nose, compressed cranium, and crisped or woolly hair. This race is chiefly confined to Africa, but, strange to say, is met with again, after an interval of a thousand miles, in the Alfourons, inhabiting one of the islands of the Indian Ocean, and on the coast of New Guinea, in the Papuas. I am inclined to believe, however, that these isolated blacks, instead of being wanderers from the torrid regions of Africa, are of

Mongolian extraction, and owe their difference of appearance to barbarism and climate.

Much has been said of the inferiority of the negro intellect, but there seems no ground for believing, with the opponents of the theory of a common descent, that, when properly cultivated, it is not capable of very high development. Considering how long the negro has been steeped in moral and physical debasement, it is unreasonable to expect, that the first rudiments of education should convert him at once into a philosopher and a *savant*. We must look for this result to time, and to the effect, not of learning only, but of Christianity. In my intercourse with negroes, I have often met with a degree of intelligence that, bearing in mind all the circumstances of their condition, has struck me with surprise, and which inspires me with a firm hope that they will one day approve themselves worthy descendants of our common parents. Let us labour with diligence to accomplish this desirable end, and not be turned aside, when we have already made some progress,

by the insolence and ingratitude of the poor, untutored savage, but with all patience and long-suffering, continue our efforts, and lead him, by the mighty beacon of the Cross, to take his proper place among the sons of men.

XIV.

THE HUMAN FRAME.

KNOW THYSELF, said the great heathen; and the lesson thus enjoined, though it has employed the energies and engrossed the attention of the wisest and mightiest spirits of every age, is not yet mastered. Man, after an interval of thousands of years, is still the noblest study of man, and remains a problem to himself. We turn from the grand spectacle of the universe, with all its untold wonders, to contemplate ourselves; and find, in the exquisite mechanism of the human frame, the extent of its capacity, and the range and variety of its faculties, an object as full of

mystery as of interest. Nature is everywhere marvellous, but in man we behold her foremost work.

The human form divine, as it has been beautifully named, is composed of a porous tissue, and four chemical elements, essentially requisite to an animated being. These are, besides the tissue, the cellular membrane, the muscular fibre, the medullary matter, and the blood.

The cellular texture consists of a number of minute cells, opening into each other, and forming the whole outline, or frame-work, of the body, which, by the tension of the other parts on the cellular fabric, is restricted to certain definite limits. The texture is formed of a substance called *gelatine*, which may be reduced by boiling to a liquid, and on cooling, presents the appearance of a jelly. It furnishes the principal material for membranes, fibres, vessels, muscles, and bones.

The body is sustained by a structure of bone, called the skeleton, adapted equally for the

purposes of organic action, and the protection of the various organs. Within this stately dwelling, protected at all points by intersecting ramparts, resides the principle of life, acting continually on its three great ministers, the heart, the lungs, and the brain.

The bones, which are 240 in number, are linked together by seams, or sutures, by a gristly substance called cartilage, and by fibrous bands termed ligaments. Those of the head, the first anatomical section, rise in an arch over the brain, constituting what is called the cranium, or skull, within which, as in a fortress, the great medium of thought and action safely reposes. Hence fourteen bones descend, like the portcullis of the castle, to form the face, branching off into cheeks, nose, mouth, and jaws, the last of which, in full-grown persons, are furnished with thirty-two teeth, sixteen in each jaw. The back-bone, or spinal column, the great pillar of the body, is the basement of this noble structure. It is formed of twenty-four distinct bones, seven of which, rising above the trunk,

compose the neck, while five descend into the loins. The twelve central bones, united in the column of the back, supply a scaffold for the ribs, which sweep round in a half-circle, twelve on each side, to the breast bone, inclosing the vital recesses of the chest. The breast bone is surmounted by two collar bones, one on each side, which connect it, like a clasp, with those of the shoulder, two bones of triangular shape, descending to the seventh rib. These are the roots of the arms; and the upper fabric of the shoulder, adjoining the second rib, is indented with a socket, in which the ball-joint of the arm is inserted. Below all comes the pelvis, composed of the five hip bones, forming the last section of the trunk.

From the trunk depend the extremities, the branches, as it were, of this tree of life. A long cylindrical bone, called the humerus, linked by the elbow joint to two bones of similar shape, forms the arm, which terminates in the wrist, a bracelet of eight bones, so united as to admit of the utmost freedom of move-

ment. This is the key to the hand, a masterpiece of mechanism, consisting of five bones, in almost parallel lines, four of which lead to the fingers, while the fifth, the shortest of the bunch, joins the thumb. The fingers, so beautifully flexible, and so exquisitely sensitive of touch, are each composed of three bones, but the thumb has only two, and these are disposed differently from those of the fingers, giving greater variety and power of movement.

The thigh bone, the most important in point of size, and perhaps the strongest in the frame, is of cylindrical shape, and is joined at the knee to the two bones of the leg, which terminate in the foot, composed of seven bones, guarded from injury above by an arch, not more remarkable for its beauty of appearance than its durability and strength. The fourteen bones of the toes complete the extremities.

This framework of bone is linked together by joints, lubricated by membraneous secretions, and is penetrated, at different points, by

blood-vessels and nerves, and put in motion by muscles. The muscles are the springs and works of the body—the machinery, so to speak, by which the overruling brain accomplishes its will. They are upwards of 500 in number, and are composed, in great part, of fibres and layers, traversed by blood-vessels, and amply supplied with nerves. Some act spontaneously, as those of the heart and intestines, requiring no interference of the will; others are swayed by the brain, through the medium of the nerves; and not a few, as those of the respiratory organs, are partly involuntary and partly spontaneous.

The skeleton is mantled in a membraneous covering, called skin, consisting of three distinct layers, the cuticle, the mucous fluid, and the cutis. The outermost is the cuticle, an albuminous membrane, composed of a number of scales, or pores, so minute as to be visible only through a microscope. It is lined by the mucous fluid, a secretion from the membrane beneath, which it protects, by its soft, jelly-like substance, from external injury, while

it imparts to the outer and semi-transparent skin its peculiar tint, whether red, black, brown, or white. A network of nerves, glands, and blood-vessels, nowhere presenting a single perceptible opening, forms the cutis, or true skin, the innermost envelope of the frame, from which the organs of touch, and the glands secreting the waste of the blood, as well as the lubricatory and absorbent vessels, penetrate to the outer covering, and consummate their several functions. Absorption, however, is very imperfectly effected through the cuticle, though on its removal, as in cases of vaccination, the function is promptly discharged by the subordinate layers, through which matter of any kind may be introduced into the system. Perspiration is the chief function of the cuticle, for which its structure, formed entirely of numberless minute pores, is admirably adapted, and to such an extent is it carried on, that nearly forty per cent of the food we consume is exuded through the skin.

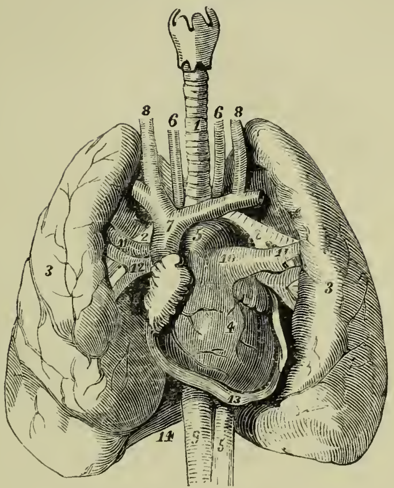
In the spacious cavity of the chest, guarded

by its breastplate of bone, throb the heart and lungs, the chief organs of vitality. The heart is the temple of life, within which, as in a sacred fane, the vital spark is first kindled, and finally becomes extinct. It is a muscular formation, intersected by compartments, the contraction of which, by an impulse residing in the organ, and acting successively on each, circulates the blood. The fount and source of our present existence, the heart is made also a witness to that of futurity. For a long time, philosophers, only too much inclined to the sin of Didymus, found a stumbling-block to their faith in that memorable passage of the New Testament, so familiar to all, which describes the wound in the side of the dying Saviour as pouring forth blood and water; and it was alleged that such a thing could not have happened, as the issue from the wound, if the frame of the Redeemer perfectly resembled our own, would necessarily have been blood only. But Science has risen up, like a holy apostle, to testify to the truth of Christianity. The discharge from the heart would

indeed have been blood alone; but it is now known that the great reservoir of the vital fluid, from which a ruddy stream is circling continually through the veins, is invested by a hollow, purse-like membrane, called the pericardium, containing a small quantity of clear water, and consequently the issue from the divine wound must necessarily have comprised both water and blood. By such seeming accidents are the authority and truthfulness of the Scriptures established and vindicated.

The heart is crowned by an arch, called the aorta, the duct that, by means of arteries and vessels, conveys a supply of blood to the head and extremities; and on either side lie the lungs, the conduits of the well. The lungs are the organs of respiration; and rise from the diaphragm, the basement of the chest, to the level of the first rib, draping the sides of the whole interior like a cloak. Air, received by inspiration, purifies the blood in its passage through the vessels of the lungs, when, having imbibed a certain quantity of poison, it is carried

ORGANS OF RESPIRATION.



1. The windpipe, or trachea, for conveying air to the lungs.
2. Branches of the windpipe, called the right and left Bronchus.
3. The lungs.
4. The heart.
5. The aorta.
6. The carotid arteries.
7. The Superior Vena Cava.
8. The Jugula Veins, which bring back the blood from the head.
9. The Inferior Vena Cava.
10. The Pulmonary Artery, for conveying the blood to the lungs.
11. Right and Left Branches of the same.
12. The Pulmonary Veins, for bringing back the blood from the lungs.
13. Section of the Pericardium.
14. The Mediastinussa, or space between the lungs.

off by expiration, and a fresh supply inhaled, which is immediately subjected to the same searching process.

The blood, thus carefully ventilated, is a colourless fluid, containing a number of bright red globules, which give it the appearance of a ruddy stream. It is the medium through which sustenance is received by the body ; and, circulating incessantly through the veins, conveys to every part in succession, from one extremity to the other, the nutriment extracted from the food. Thus the muscles, fibres, and flesh, composing the various organs of the frame, are continually strengthened and nourished ; and, when the blood ceases to perform this function, the whole structure breaks down, and the principle of life expires.

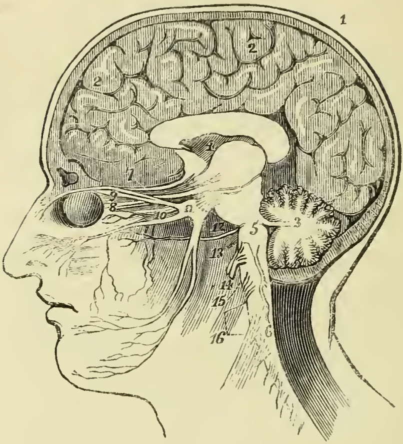
The blood in the body of an adult is said to weigh twenty-eight pounds, and traverses the round of the veins, from the great basin of the heart, in little more than two minutes, so that the heart discharges about a hogshead daily. The vital fluid is supplied with air through the

trachea, or windpipe, the shaft of the lungs, proceeding direct from the mouth; and behind this lies another passage, the pharynx, communicating with the esophagus, the avenue by which food is conveyed to the stomach.

The stomach is a sort of bag, formed of two duplex coverings, so constructed that, on the introduction or ejection of food, they can expand or contract at will. The food, moistened by the saliva of the mouth, is here met by the gastric juice, a secretion from the vessels of the internal mucous membrane, by which it is dissolved, and another infusion, called the pancreatic juice, then separates the nourishment from the waste. The reserved portion, so carefully and effectually extracted, is absorbed by the small intestines, while the large intestines receive the other, and pass it off by excretion.

The liver, a glandular mass in the upper region of the abdomen, plays an important part in the process of digestion, and is the alembic of the bile, from which, when secreted, the bitter fluid passes into the gall-bladder. Chyle is

THE BRAIN AND CRANIAL NERVES.



1. Section of the Brain, exhibiting its convolutions.
2. The Cerebrum, or upper portion of the brain.
3. The Cerebellum, or little brain.
4. The Ventricles.
5. The Medulla Oblongata, or expansion of the Spinal Cord.
6. The Spinal Cord.
7. The first pair of nerves, called the Olfactory.
8. The second pair of nerves, called the Optic.
9. The third pair of nerves, called the Common Motor.
10. The fourth pair of nerves, called the Trochleares.
11. The fifth pair of nerves, called the Trifacial.
12. The sixth pair of nerves, called the Abducentes.
13. The seventh pair of nerves, called the Auditory.
14. The eighth pair of nerves, called the Pneumogastric.
15. The ninth pair of nerves, called the Lingual.
16. Roots of Cervical Nerves.

*** The brain is inclosed in three membranes, the outer called the Dura Mater, the middle called the Arachnoid, and the inner called the Pia Mater.

produced in the duodenum: and after traversing the lacteals, and the mesenteric glands, pours through the thoracic duct into the heart.

Four of the senses—sight, hearing, taste, and smell—reside in the head; and their respective organs—the eye, ear, tongue, and nose—are linked by the cranial nerves to the brain, the seat of sense, thought, and will. Another branch of the nervous system, called the spinal cord, descends from the brain into the back bone, and connects it with the remote nerves of the extremities.

The brain is an oval-shaped mass, guarded by a membraneous stay, called the dura mater, which, passing across the skull, divides it into two hemispheres, and also separates the upper from the lower compartment. The upper portion, which has the greater dimensions, bears the name of the cerebrum, and is parted beneath the surface into three lobes, the back, front, and central. The lower portion is called the cerebellum, and is also disposed in lobes, though, from the reduced size of

the mass, they are not on the same scale of magnitude.

The brain is the throne of the soul, from which its decrees are sent forth, for good or evil, through every region of the frame. Here Reflection sits, like a reverend hermit, in the silent recesses of the brow; here Imagination spreads her wings, and Genius prompts and directs her flight. Beneath the dome of this sacred temple, the adoring spirit looks gratefully up to its Creator; and here too often his majesty is outraged, and his holy laws violated and contemned.

Volumes might be, and indeed have been, written, on each member of the body, and yet leave something more to be said of the delicacy and exquisite finish of its mechanism, and the beautiful adaptation of part to part. We need go no further for a complete and triumphant answer to the idle theory of Lamarck, which would make nature, in all its endless aspects, the offspring of spontaneous generation, and distort its very harmony into an element of

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THE END.

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